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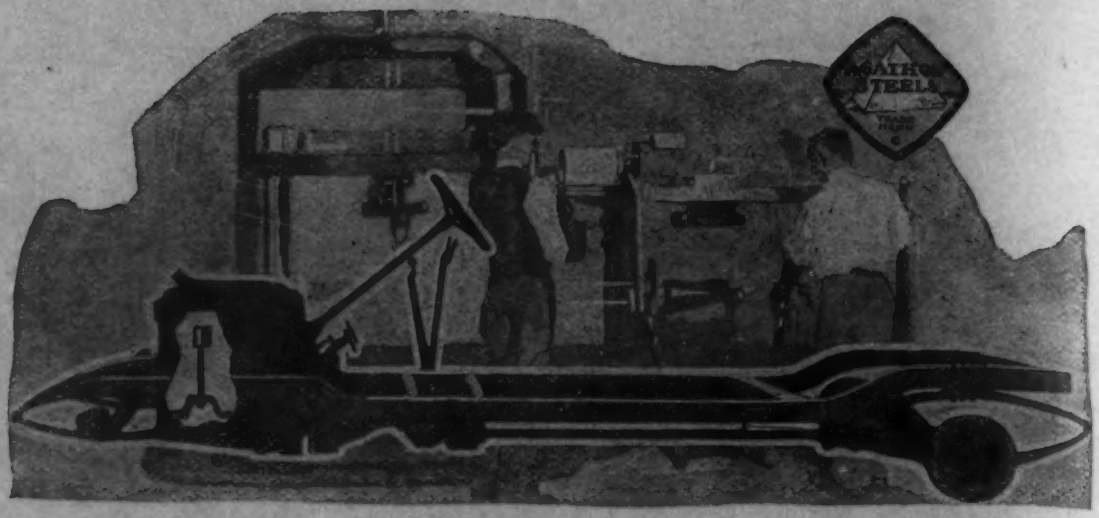

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Cleveland, Detroit, Syracuse, Philadelphia, Chicago

UMA-2

TRANSACTIONS
of the
American Society for Steel Treating

Vol. II Cleveland, July 1922 No. 10

SECTIONAL MEETINGS A SUCCESS

JUDGING from the excellent attendance and keen interest which has been shown at the New York and the Pittsburgh Sectional meetings the board of directors is to be complimented for their wisdom and foresight for having established these between convention meetings. Members from many parts of the country were in attendance at each of these two-day sections and many expressions commending the meetings were heard. The large amount of discussion which followed all of the papers which were presented indicates very clearly that a keen interest prevails and that the sectional meetings have become a permanent part of the Society's program of activity. Each of our chapters should be looking forward to the time when they will be the hosts for one of the sectional meetings. It is surprising how much the work of the Society means to everyone especially to those who are preparing and planning a meeting, trips of inspection and entertainment for visitors. It throws the members of a local chapter into a more intimate relationship and cannot possibly result in anything but unbounded success for the individual members, the local chapters and the national Society. May we all look forward to the next sectional meeting which will occur around the first of the next year.

RESEARCH

COMMENDABLE work is being done by the National Research Committee of the American Society for Steel Treating under the able chairmanship of Lt. Col. A. E. White, who has succeeded in having appointed by all of the chapters a local sub-committee on research to serve in an advisory capacity. Among the many opportunities for service to this group of exceptional men is the preparation of a list of subjects and which offer possibilities of research upon which it is desirable to work. The preparation of this list of subjects will be valuable in many ways, one of the most important of which will be that of affording suggestions to educational institutions and students on topics for investigation in metallurgy.

The metallurgical department of Case School of Applied Science under the efficient direction of Professor H. M. Boylston has already produced a number of very interesting investigations. These have been conducted not only at the school laboratory but also in the laboratories of various industries of Cleveland that have been placed at the disposal of the institution. An excellent exhibition of co-operation deserving of greater emulation.

Many other educational institutions have expressed a desire to co-operate with Colonel White and his committee and it is believed and expected that this phase of the Research Committees' work will continue to grow in volume and in importance.

TECHNICAL SOCIETIES TO WORK WITH THE BUREAU OF STANDARDS

THE spirit of co-operation which is being manifested in the formation of a committee representing numerous technical and scientific societies to work in harmony with the United States Bureau of Standards, is something we are pleased to see. Such an intimate relationship with the bureau can only result in a marked betterment for scientific research with a very much less duplication of effort on the part of all concerned. In the past a great deal of research work has been conducted by many different institutions with a result that much of the work was duplicated which means both a waste of energy and money. With this new relationship between the bureau and the many societies and associations we look forward to a very decided benefit to all and a marked saving in the total amount of money which will be expended in carrying out the researches.

It is patent that concerted effort makes for efficiency therefore with a close co-operation of all parties involved a long stride for the improvement of our scientific knowledge will be the reward.

FOOTPRINTS

THE study of biographies and accomplishments of distinguished men is one of the requirements of the University of Pittsburgh for students in the engineering divisions. This phase of the work was very forcibly presented by Chancellor Bowman when he spoke before the Pittsburgh Sectional Meeting of the Society.

One may readily understand the inspiration obtained from the study of the biographies of such distinguished men as Washington, Lincoln and Stanley. The vicissitudes and struggles they had to meet as well as their ability to accomplish successfully problems presented, could not but help impress the reader and form in his sub-conscious mind a resolve to emulate and endeavor to accomplish something worth while so that his life might also be a means of inspiration and guidance for future generations.

While the late Dr. Howe did not have to undergo the trials and tribulations of early youth as Lincoln did, nevertheless the perseverance and steadfastness with which Dr. Howe undertook and continued his researches in iron and steel demonstrated that his early education and training had been along lines designed to accomplish successful results.

The life of Dr. Howe and the results of his many researches and discoveries should be studied with careful thought, keeping in mind always that a research is not finished until it has been viewed from all angles and most exhaustively studied.

The metallurgical profession will view the life and accomplishments of Dr. Howe as a source of continued inspiration, and will gather from these a desire to contribute to the advancement of progress in iron and steel. While the loss of Dr. Howe is great and appalling, one may nevertheless take comfort in the thought that his works will live after him and that:

"Lives of great men all remind us
We can make our lives sublime,
And, departing, leave behind us
Footprints on the sands of time."

THE QUESTION BOX

UNUSUAL interest is being shown in the Question Box Department of the TRANSACTIONS. We have had many favorable comments from our membership. We frequently hear the statement, "I am particularly interested to see the answers to the this or that question." It is gratifying to know that a growing interest is being stimulated through this feature of our publication, however we are not getting the support from the membership as a whole either in the receipt of questions or answers to questions. Undoubtedly a large number do not realize they can contribute to the enlargement of this department.

The Question Box is intended for your use and it is urged that you avail yourself of the opportunity of making it work for you. Probably there are some members who would like to contribute answers but who feel that they do not care to have their name appear as a contributor. In this respect a new policy has been adopted whereby the author's name will be withheld and retained in our files, in cases where he makes such a request. Your confidence and co-operation in making not only this feature but all other features of the TRANSACTIONS a success is the one way in which the Society will progress and attain the goal for which we are aiming.

A NEW PRODUCT

IF a new product is to be placed upon the market and the sale of it is to have sufficient success to repay the manufacturer, it is first necessary that the product should be thoroughly tried out in order to determine whether or not it is well suited for the purpose it is intended. Every year many new products are placed upon the market not only of mechanical devices but also of human beings.

Each year the technical schools are turning out many young men who during their junior and senior years have specialized in metallurgical subjects and when they have received their degrees are placed upon the market for consumption in the various steel manufacturing and fabricating plants. There is no objection to the quality and quantity of work given to and performed by these embryonic metallurgists, the great difficulty being the unwillingness of these individuals to permit themselves to be thoroughly tested and tried out before demanding a compensation for their services entirely out of proportion to what they are able to deliver.

One university of repute graduating twenty-three individuals from the metallurgical department has so far succeeded in placing but five of the number. While many opportunities have been offered to these graduates to obtain minor positions in the laboratories of steel mills and government bureaus, they have nearly all declined because the remuneration did not seem to be in proper proportion to their own estimate of their value. There is a grat responsibility resting upon educational institutions to impress upon the members of their graduating class that before they may rise above the 'common herd' it is necessary for them to demonstrate their ability and that during this process they should consider salary as of minor importance and the opportunity to apply in a practical way the technical information they possess as the greatest in importance.

DETROIT CONVENTION

THE General Convention Committee of the Detroit Chapter of which Billy Woodside is chairman, held a very important meeting at the D. A. C. Club on June 16 when the chairmen of the various sub-committees gave reports of progress.

W. P. WOODSIDE

The Papers Committee of which Mr. C. N. Dawe is Chairman, advised that the Committee had been very successful in obtaining a large number of very high class papers and that it was sure a great amount of interest and discussion would be brought forth because of the originality and diversity of the subjects presented.

Mr. D. J. Crowley of the Hotels Committee stated that the hotels were beginning to receive very heavy reservations and that it was advisable that all members should make their reservations as soon as possible for Convention week. Some members have experienced difficulty in securing single rooms with bath because of the tendency on the part of the hotels desiring to have at least two in a room. In case any of the members should have difficulty in securing the accommodations they wish, Mr. Crowley suggested they should write him direct at 832 Dime Bank Building, Detroit, and he would see they were properly taken care of.

The Finance Committee under the direction of Mr. C. T. Bragg has plans arranged for the securing of sufficient money so that the entertainment features of the convention will be very ably taken care of.

The Entertainment Committee of which Mr. Frank G. Davis is chairman, has formulated a program that will keep the members enjoying themselves from the time they land until they leave the Motor City.

The Plant Visitation Committee has arranged a number of very interesting visits to some of the largest heat treating and forging plants in Detroit. Plant visitation in itself will be well worth a trip to the Michigan Metropolis because it will be possible for the members to visit plants during October 2nd to 7th that otherwise they would be unable to see.

The ladies are not to be neglected but it is assured that they will have as enjoyable a week as they have ever had at any previous convention and the conventions of the Society have been noted for the excellent manner in which the ladies have been taken care of. Larry Learmouth will have charge of this phase of the convention.

The Transportation, Information and Publicity Committees also presented encouraging reports and told of the plans they had worked out for securing the proper results by their committees at the appropriate time.

Mr. Jack Dailey, Chairman of the Local Exhibit Committee presented his report showing that all of the spaces originally shown on the floor plan had been sold and that it was necessary to open up additional booths so that all exhibitors who desired to show their products could be accommodated.

All indications point to the largest convention and exhibition the

Society has ever held and there is no doubt but that members should begin to make their plans now so as to be able to attend.

REPORT OF PITTSBURGH SECTIONAL MEETING

THE second of our sectional meetings which are held in various parts of the country was held in Pittsburgh May 25 to 27 at the Bureau of Mines. About 250 members of the Society from various chapters throughout the country were in attendance.

The first session scheduled for Thursday afternoon, May 25 was opened by N. B. Hoffman, metallurgist, of the Colonial Steel Company and chairman of the Pittsburgh Chapter who extended an address of welcome to the visiting members and guests on behalf of the Pittsburgh Chapter.

Following this address of welcome the meeting was turned over to Dr. C. M. Johnson, Chief of Research, Park Works of the Crucible Steel Company of America, Pittsburgh, who was chairman of the session. After a few fitting remarks, Professor F. F. McIntosh, metallurgical department of the Carnegie Institute of Technology was introduced and presented his very capable paper entitled "Fibre in Steel and Iron". Prof. McIntosh's paper compared the structure of wood and steel and noted that metallurgists seldom consider fibre of importance. Prof. McIntosh pointed out that fibre goes back to the ingot and is determined to a large extent in the furnace and the ingot mold, and that subsequent rolling and deformation does not increase or decrease its presence. He made the plea that the metallurgists be allowed more freedom in specifying the manner in which the steel he has to heat treat should be manufactured. Numerous micrographs accompanied the presentation of this paper and are included in Professor McIntosh's paper which is published in this issue of the TRANSACTIONS. A lengthy and interesting discussion followed this paper.

Following Prof. McIntosh, a paper entitled "Factors Influencing Mass Heat Treatment" was presented by W. B. Crowe, who is metallurgist of the armor plate department of the Carnegie Steel Company, Homestead Works, Munhall, Pa. Mr. Crowe's paper and discussion is also published in this issue of the TRANSACTIONS.

The last paper presented at the Thursday afternoon session was entitled "A Discussion of Impact Testing Methods and the Results Obtained", by John M. Lessells of the Westinghouse Electric & Mfg. Company. Mr. Lessells' paper was published in the May issue of the TRANSACTIONS. The discussion which followed his presentation is to be found in this issue of the TRANSACTIONS.

Thursday evening somewhat over 100 members and guests of the Society assembled at the University Club where an informal banquet was served. It was a regular heat-treaters banquet as evidenced by the following menu:

MENU

Austenitic Puree ala Mongole

Celery Ghosts Ferritic Olives

Filet of Grain Refined Sole
with Dephosphorized Sauce

Open Hearth Vermont Turkey
with Electric Furnace Cranberry Sauce
Bessemer Sweet Potatoes
(Southern Crucible Style)
Spheroidal June Peas
Dendritic Lettuce
with Desulphurized Roquefort dressing
Frozen Puddled Custard
Pearlite Cake Demi Tasse Quenching Oil
Havana Smoke Stacks

Prof. A. E. White of the University of Michigan and past-president of the Society presented G. H. Neilson, President of the Braeburn Steel Company, Braeburn, Pa., and past president of the Engineer's Society of Western Pennsylvania, who presided over the meeting as toast-master. A very entertaining evening was enjoyed by all. The speakers included Dr. John G. Bowman, Chancellor of the University of Pittsburgh, Prof. Frederick Crabtree of the Carnegie Institute of Technology and Dr. John A. Mathews, President of the Crucible Steel Company of America. Dr. Mathews delivered a very interesting address entitled "Metallurgical Miscellany". This banquet and meeting was declared by all who attended as a decided success.

Friday morning, the members in attendance assembled at the William Penn Hotel where they were assigned to automobiles furnished by the members of the Pittsburgh Chapter and were taken to the Edgar Thompson plant of the Carnegie Steel Company where they reviewed the rolling of steel shapes, the blowing of Bessemer steel, and the melting of open hearth steel. Following the inspection of this plant, the visitors were escorted through the plant of the Westinghouse Electric & Mfg. Company and at noon time were served with a very delicious luncheon in the cafeteria. After the luncheon a short trip was conducted through the coil winding and electric locomotive departments of this plant. At 2 o'clock the party proceeded by automobile to the Bureau of Mines Building where the final technical session was held.

Professor H. M. Boylston, Case School of Applied Science, Cleveland, presided over this session. A. M. Cox, President and Treasurer of the Pittsburgh Commercial Heat Treating Company presented his paper entitled "The Abrasive Qualities of Plain Carbon and Alloy Steels". This paper was well received and rather freely discussed. It was published in the May issue of the TRANSACTIONS.

Following Mr. Cox, John A. Succop of the Heppenstall Forge and Knife Company, Pittsburgh, presented his paper entitled "Importance of the Proper Heating and Cooling of Steel", which was also published in the May issue of the TRANSACTIONS. The discussion of Mr. Succop's paper is to be found in this issue.

A paper entitled "'Manufacture of Springs" by D. A. Smith of the Union Spring and Manufacturing Company, New Kensington, Pa. was read by title, as Mr. Smith was confined to his bed due to illness.

The last paper of the session was delivered by M. A. Grossmann metallurgist of the Electric Alloy Steel Company, Charleroix, Pa., and was entitled "The Change in Dimensions of High Speed Steels in Heat Treatment," published in the May issue of the TRANSACTIONS. This paper brought forth a large amount of interesting discussion and proved to be a subject in which many of the members were very much

interested. Mr. Grossmann handled the discussion in a very capable manner and his discussion likewise appears in this issue of the TRANSACTIONS.

Friday evening those in attendance were entertained by the Pittsburgh Chapter at a smoker in the Bureau of Mines Building. A very interesting and entertaining evening was enjoyed by all after which a buffet luncheon was served.

Saturday morning, the Board of Directors assembled for a business meeting.

SOCIETIES TO CO-OPERATE WITH BUREAU OF STANDARDS

IN order to keep in close contact with the iron and steel industry so that investigations conducted by the Bureau of Standards will be along the lines meeting the needs of the industry in general and pertaining to the fundamental properties of iron and steel, an advisory committee on ferrous metals has been appointed to work in close contact with the Bureau. This committee is made up of representatives of several scientific and technical societies interested in iron and steel. The societies represented by this committee are the American Society for Testing Materials; the American Institute of Mining and Metallurgical Engineers; the American Association of Steel Manufacturers, Society of Automotive Engineers and the American Society for Steel Treating.

On June 2, this Committee assembled for a conference at Washington, D. C. The following men were present representing their respective societies:: Bradley Stoughton, Consulting Engineer, New York, and Dr. John A. Mathews, President of the Crucible Steel Company of America representing the American Institute of Mining and Metallurgical Engineers; H. T. Morris, Bethlehem Steel Company, South Bethlehem, Pa. representing the American Society for Testing Materials; E. F. Kenney, Midvale Steel & Ordnance Company and Hugh P. Tiemann, Carnegie Steel Company representing the American Association of Steel Manufacturers; G. E. Norris, representing the Society of Automotive Engineers; Prof. A. E. White, Director of Engineering Research, University of Michigan and T. D. Lynch, Westinghouse Electric & Mfg. Company, East Pittsburgh, representing the American Society for Steel Treating.

A. A. Stevenson, member at large and J. H. Parker representing the American Society for Testing Materials were unable to be present.

There were present at the meeting from the Bureau of Standards: Dr. S. W. Stratton, Dr. G. K. Burgess, Dr. Hildebrand, H. J. French, Mr. Caine, Mr. Lundell, Dr. Rawdon, Dr. Jordan and Mr. Freeman.

Dr. Burgess had prepared a very comprehensive program to be reviewed by the committee. The discussion was opened by Dr. S. W. Stratton who gave an interesting talk on the purpose in bringing this committee together, stating that it was the desire of the Bureau to get first-hand information as to what problems, along metallurgical lines are potent and which should be investigated, and to get such help as the committee could give in placing the work of the Bureau on the best commercial basis possible. He referred to the non-ferrous committee which had been working for about a year and one-half and stated that

this work had been a very great help to the Bureau with the result that considerable had already been accomplished in connection with this work. As to the action of this committee it was pointed out that other societies in addition to those already represented might probably be added to the committee personnel. Such societies as the American Foundrymen's Association; American Railway Association; the American Electrochemical Society and the National Research Council were suggested. It was also suggested that the appointment on this committee of a few individuals might be especially desired on account of their associtaions, namely Dr. Albert Sauveur, of Harvard University, Dr. Wm. Campbell of Columbia University, and Frank Carney, consulting metallurgist of New York.

The question of time and frequency of meetings was discussed and it was thought advisable to have meetings about once every six months, one in the fall and the other in the spring in order to keep in touch with the work the Bureau is doing and also to keep the Bureau in touch with the work that others are doing throughout the country.

The question of numbering of steels was taken up and discussed at some length with reference made to the work which the Standards Committee of the American Society for Steel Treating is doing and the work that the Society of Automotive Engineers has already done in standardizing the numbering of steels. The Bureau expressed a desire to hear from different organizations as to what part they might probably play in such a standardization.

Mr. Norris brought out that the Society of Automotive Engineers felt that the work which they had already done is for the present at least, quite satisfactory to that organization and that if any change from their present scale were made, it should be very carefully considered before being established, but he did think that the Bureau could accomplish good work in establishing this numbering system, and making it a clearing house to which additional numbers might be added from time to time.

Dr. Hildebrand reviewed the methods which had been adopted by the Bureau in establishing and distributing standard chemical samples and asked for any suggestions that might add to the improvement of the method now in use.

Dr. Jordan gave a talk on the subject of gases in steel and how to determine them and the changes which take place in heat treatment due to the presence of these gases.

Mr. Freemann discussed rolling mill problems, the amount of reduction and its effect upon steel.

Mr. Fletcher gave a talk on the values of steels at high temperatures and stated that the engineers at the Bureau were in a position to make tests on steel while at high temperature and determine its physical properties under these conditions. Mr. Freeman discussed the tests which had been made upon railroad materials and he went into considerable detail on a lot of the tests that are now being run, covering thermal stresses in wheels, wheel composition, titanium treated rails, ingot practice, etc.

Dr. Jordan reviewed the subject of iron-carbon-manganese alloys bringing forth the work that is now being done by the Bureau.

The corrosion of chrome steels was discussed by Dr. Rawdon who reviewed the work which the Bureau has done relative to the corrosive

qualities of different steels and the importance of having steels that did not corrode, and their use in measuring apparatus and other places where corrosion causes trouble. He also discussed the subject of testing wrought iron and importance of more definite methods of testing this material stating that the old methods had become antiquated and that the results obtained did not reveal the real merits of wrought iron.

Mr. French discussed tests of high speed tool steels covering the important features and steps to be taken in obtaining standard bars on which to test high speed steel. There was a consensus of opinion of those present that in general it is necessary to test steels according to the type of work it is intended the tools are to perform giving as nearly as possible the working conditions.

It was stated that the Bureau has associates working with the Bureau and maintained by different manufacturing organizations for the purpose of working out their problems and with the provisions that the findings are at some later date published. The companies maintaining these associates obtain the benefit of first-hand information and are enabled to use these data before this knowledge could come into the hands of any competitors.

As this meeting was called primarily for the purpose of organizing and outlining the possible actions of the committee and the method of attack to be used, no definite action was taken. The thoughts conveyed by the various members of the Bureau of Standards were left as food for thought to be more minutely discussed at the next meeting.

Following the adjournment of this session the visiting committee was escorted through the laboratories of the Bureau.

SHOW YOUR COLORS

NOT so long ago a gentleman from Chicago had occasion to go abroad. While the liner was leaving New York harbor our friend was on deck scanning the sky line of the famous city, his eye happened to catch a glimpse of an emblem that a fellow passenger was wearing on his waist coat. It looked familiar and upon closer examination he found it to be similar to the one he was wearing. It was the ensignia of the American Society for Steel Treating.

The fact that each was wearing the emblem of the Society immediately placed these two men on the same plane which resulted in a very interesting and companionable voyage. When they arrived in England they inspected several steel mills and spent many profitable hours together. This chance meeting through the medium of a society emblem is not at all unique. It happens frequently and incidentally usually results in warm friendships.

The wearing of the Society's insignia places a man in a class which identifies him as a progressive student of science and technological advancement. Our society is an internationally recognized institution for the advancement of steel metallurgy and membership in the society is something of which to be proud.

The insignia of the society is familiar to most of our members, being in the form of a small circular safety clasp pin having an especially attractive arrangement of the initials A. S. S. T.

FIBRE IN IRON AND STEEL

By F. F. McIntosh

THE earliest workers with iron and steel recognized the fibrous character of these metals. It was an easily recognized characteristic and it had a marked effect upon the performance of the metals. When the scientist turned his microscope on these metals he made many interesting and valuable discoveries. He found that they were made up of grains or constituents which he named ferrite, pearlite, cementite, austenite, etc. It would be hard to overestimate the value of his work, but he worked so very close to his metal, that in many instances, he lost sight of some of its very important characteristics. You will find that some of his books say that wrought iron is not fibrous. He may tell you that it is made up of grains of ferrite and stringers of slag, and that the grains of ferrite are granular or crystalline and therefore wrought iron is not fibrous. He recognizes the true structural condition of the metal but he is very apt to overlook the influence of its condition upon its ultimate performance. He frequently fails to recognize the fibrous character of steels or its full influence upon the performance of the metal. In many instances he is not given control of the manufacturing conditions which govern the formation of the fiber or grain of his metal, and he is required in the working and treating of the steel, to secure results with material in which his only specification has been chemical composition.

If the chemist were given pieces of wood, one of hemlock and one of hickory, he would probably show no more difference between the chemical composition of the two kinds of wood than might be found between two heats of steel manufactured within the limits of an ordinary steel specification. If we were to make one sledge handle of hickory and one of hemlock the difference in performance of the two woods would be easily observed. It would be the difference between success and failure and it would be the result of differences in fibre or grain of the two woods. Differences of the same general character and magnitude exist in irons and in steels.

The metallurgist should pay more attention to the fiber or grain of his metals than he usually does, and he should take the stand "that taxation without representation is tyranny," that is, if he is to be held responsible for the working and heat treatment of the metals, he must be given control over the conditions which govern fiber. He can often work himself into the proper position, in this respect, and without revolutionary methods, if he makes the examination for fiber a routine inspection just as he now requires a chemical analysis or a tensile test.

The object of this paper is to direct attention to the importance of fiber in the performance of iron or steel under test or in service, and to indicate the factors which govern its formation and character. The paper has been suggested by the many instances which have been observed where chemical composition and treatment of metal have been according to specification, but the metal has failed to stand up in service. An examination for fiber often shows the cause of failure. It has been observed that in many instances the metallurgist neglects this examination, and, in his great interest in the microstructure, overlooks the importance of fibre or grain as shown by methods of macro-etching. The importance of this subject cannot be over-

A paper presented at the Pittsburgh Sectional meeting, May 25-27. The author Prof. F. F. McIntosh, is professor of metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

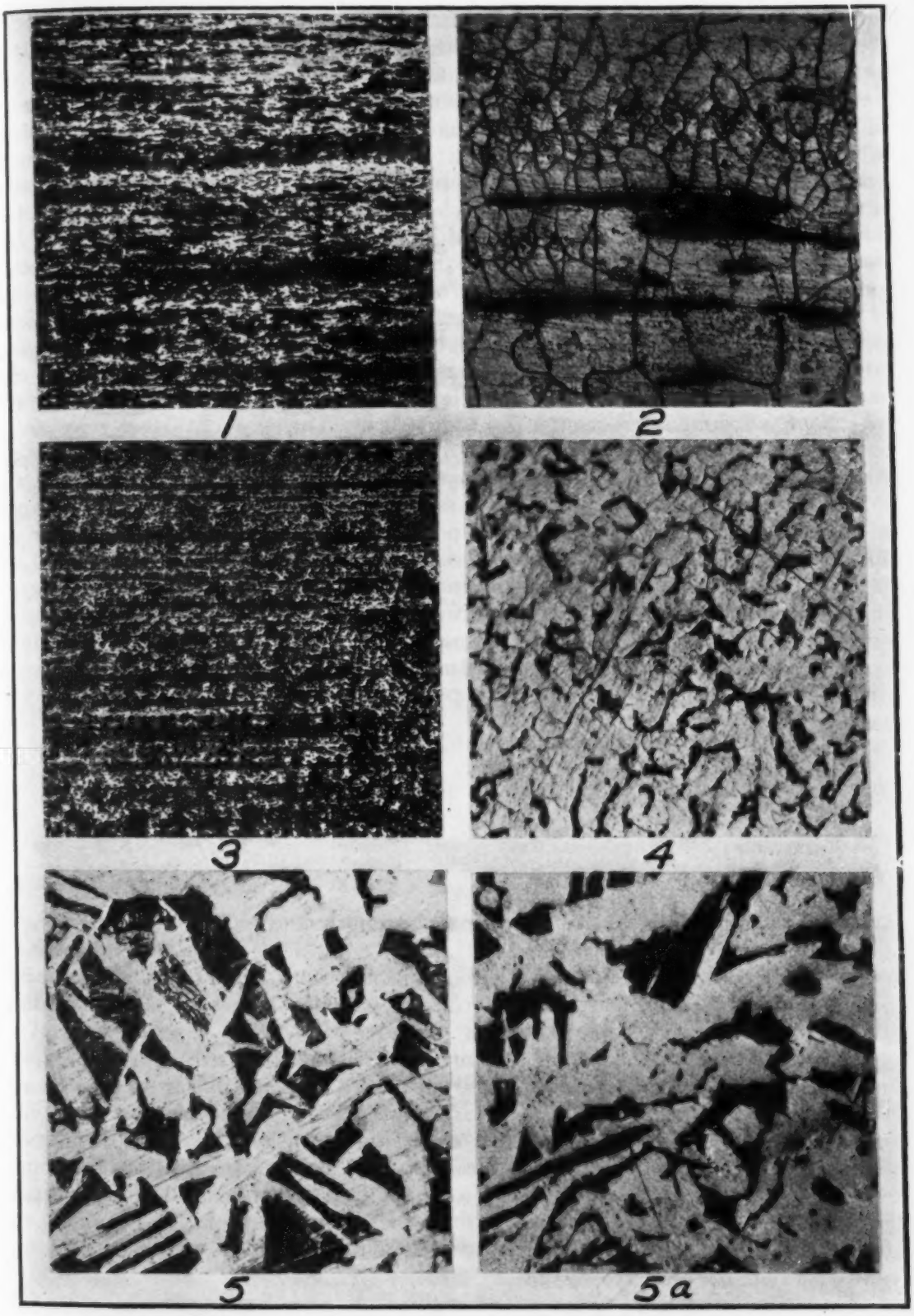

Fig. 1—Macrostructure of a longitudinal section of wrought iron showing the decidedly fibrous condition of the metal, 3.6X. Fig. 2—Photomicrograph of a longitudinal section of wrought iron showing stringers of slag and ferrite grains, 150X. Fig. 3—Macrostructure of a low carbon steel showing the fibrous nature of the material, 3.6X. Fig. 4—Photomicrograph of a low carbon steel showing only faint traces of fibre as disclosed by small thread-like nonmetallic inclusions. Fig. 5—Photomicrographs of a transverse section of a steel plate, rolled in two directions, showing the absence of fibre. Fig. 5a is a longitudinal section of the same plate. 150X.

emphasized. A recognition of its importance and an intelligent control of it under manufacturing conditions would often mean a big improvement in quality of product and a saving through improved performance of metal and fewer failures in service. Intelligent control can only be obtained by a thorough and correct understanding of the character of fiber and all of the factors which govern its formation. The practical man and experienced manufacturer who recognizes fiber and sees, in a measure, its importance, should demand the co-operation of the metallurgist who understands its causes and character. There has been too little of this kind of co-operation. The metallurgist has held too close to the laboratory and his microstructure. The manufacturer has been too much absorbed in the problems of production.

In all lines of manufacturing activities we are facing a most serious situation in the form of German competition. A study of the German methods will show many reasons for his success. The outstanding reason, the one which will be the cause of much of our worry, goes back to the fact that he has applied science to his industries. The fiber in steel may seem like a small detail, but, if a German rail performs better in service than an American rail, the difference in fiber might readily be the cause, and the result be the loss of South American rail contracts. It is hoped that this paper will succeed in indicating the importance of the subject. In a short paper of this kind it is impossible to make a thorough and comprehensive exposition of the subject, however, we shall, by means of photographs and photomicrographs illustrate the subject with a few simple examples. As a first example, let us consider a piece of wrought iron, a material which we have been told is not fibrous. A comparison of longitudinal and transverse tensile tests shows a marked variation in the physical properties of the metal.

	Ultimate Strength Pounds per Square Inch	Yield Point Pounds per Square Inch	Elongation per cent in 2 inches	Reduction Area in per cent
Longitudinal	47,400	29,600	16.0	21.9
"	47,600	29,000	25.0	21.9
Transverse	32,800	22,600	2.5	5.2
"	28,400	19,800	2.0	2.4

The wrought iron has much greater strength and ductility in the longitudinal direction than it has in the transverse or across the fiber direction. When the material is etched for fiber or macrostructure it shows a decidedly fibrous appearance with the fibers running in the direction of maximum strength and ductility as shown in Fig. 1.

When the microstructure is examined the usual structure of stringers of slag and grains of ferrite are observed as shown in Fig. 2. It is desired to direct attention particularly to the fact that ferrite grains are arranged in longitudinal bands. These bands are easily distinguished by their difference in grain size, a difference which is probably the result of variations in composition. The metallic portion of the wrought iron is made up of longitudinal stringers of ferrite. The ferrite grains might be considered as similar to the cell structure of wood and the banded arrangement as representing the grain of wood or fibers of a rope.

This examination shows that wrought iron is a heterogeneous material composed of longitudinal stringers of slag and longitudinal bands of metal, and that it has much greater strength and ductility in the direction of the bands or fiber (longitudinal) than it has when tested across the fibre (transverse). Practical experience has shown many interesting results with this

material, and, in spite of the fact that many writers have said that it is not fibrous, the test of service has enabled it to hold the field in service such as stay bolts, at a cost of at least 30 per cent more than its rival. There are evidently some factors in connection with the fiber of this material which are not understood.

Whether or not wrought iron is fibrous depends largely upon the definition of the word fibrous. It is certainly made up of longitudinal stringers or films of slag and longitudinal bands or fibers of ferrite grains. Like a piece of wood or rope it has longitudinal strength, and transverse weakness resulting in flexibility. A long discussion might be developed on the use of the word fiber, however a wrangle of this kind would add little to our technical knowledge. It has been suggested that the term fiber might be used wherever the material has been extensively elongated. The author believes, however, that it would be best to abandon the word fiber entirely where metals are concerned and use the word grain. The word grain would apply equally well to either cast or forged material. The objection to the use of the word grain is that it is frequently used to refer to microstructure of the metal and every effort should be made to avoid confusing the microstructure with the macrostructure. The important thing, after all, is not so much the word used, as it is the general recognition of the heterogeneous character of the metals and the importance of this characteristic. The characteristics of fiber or grain are not confined to wrought iron. They are present in all steels and the following examples have been selected to illustrate this point. Longitudinal and transverse tensile tests were made on a sample of low carbon steel which had been rolled into a long flat section. The results of these tests are as follows:

	Ultimate Strength Pounds per Square Inch	Yield Point Pounds per Square Inch	Elongation per cent in 2 inches	Reduction of Area in per cent
Longitudinal	55,600	36,200	54.0	51.4
"	43,200	36,400	54.0	56.3
Transverse	54,700	35,200	....	33.6
"	54,900	35,000	....	42.9

There is little difference between the transverse and longitudinal strength of this material; the transverse test being slightly lower in yield point. The effect of fiber, however, shows up very clearly in the ductility of the material. The transverse samples broke outside of punch marks, but reduction of area tells the story. Fatigue or impact tests would also show a marked difference resulting from fiber. The macrostructure, Fig. 3, shows the fibrous nature of the material, the microstructure Fig. 4 shows only faint traces of fiber as disclosed by occasional small thread-like nonmetallic inclusions.

Transverse and longitudinal tensile tests from a steel plate rolled in a plate mill, rolled in two directions, from ingots designed for plate mill work indicate that fiber is absent in this material.

	Ultimate Strength Pounds per Square Inch	Yield Point Pounds per Square Inch	Elongation per cent in 2 inches	Reduction of Area in per cent
Longitudinal	62,750	36,000	34.0	50.5
"	63,450	35,500	32.5	46.5
Transverse	62,750	37,000	30.0	46.5
"	62,200	36,000	30.0	50.5

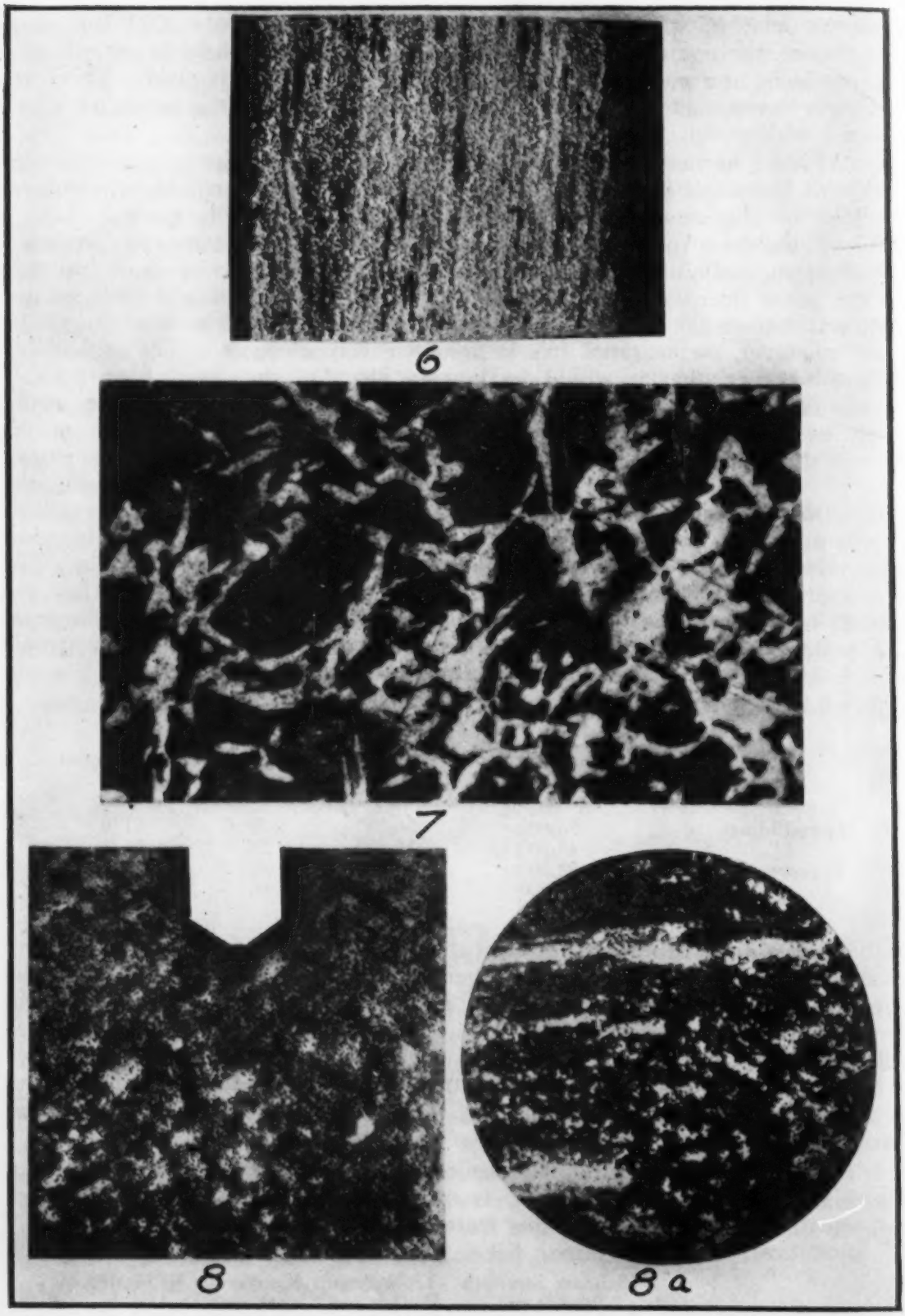

Fig. 6—Macrostructure of a longitudinal section of the steel plate, rolled in two directions, showing the elements of fibre which were well developed but not evident in photomicrographs in Figs. 5 and 5a. The fibres are present in sheets like the leaves of a book. Magnified 3.6X. Fig. 7—Photomicrograph of a transverse section of a high grade acid steel forging showing no banding or indication of fibre. 150X. Fig. 8 is the macrostructure specimen shown in Fig. 7. The presence of fibre is clearly shown. Fig. 8a is a macroetching of the transverse section of the same specimen. 3.6X.

Photomicrographs of this material, Fig. 5 and Fig 5a, taken from transverse and longitudinal specimens do not indicate the presence of fiber. Methods of macro-etching, however, reveal the elements of fiber which were well developed, as shown in Fig. 6. The fiber in this case is in sheets like the leaves of a book. The physical properties of the plate taken with reference to its length or breadth, that is, parallel to the sheets of fiber, do not show variations. If a tensile test were taken through the thickness of the plate it would be a transverse test and would give lower physical results.

Transverse and longitudinal tensile tests taken from a high grade acid steel forging containing about 0.40 per cent carbon and 0.58 per cent manganese, shows the effect of fiber.

	Ultimate Pounds per Square Inch	Yield Point Pounds per Square Inch	Elongation per cent in 2 inches	Reduction of Area in per cent
Longitudinal	91,750	48,000	24.0	36.0
Transverse	89,250	48,250	17.0	25.1

The microstructure of this material, Fig. 7, shows no banding or indication of fiber, but the macrostructure, Fig. 8, shows the fiber and explains the reason for the low elongation and reduction of area shown on the transverse tensile test. It is not difficult to trace the fiber back through the different states of manufacture. Its study affords valuable information as to the flow and working of the metal and the casting conditions. It shows that fiber or grain originates at the time the metal solidifies and that its character is determined by three main factors:

1. The condition of the molten metal
2. The conditions of solidification
3. The flow of the metal during forging, pressing or rolling

For example, take a cross section of a 4-inch x 4-inch billet. Under examination for fiber or grain, it shows the outer ring metal resulting from the dendrite growth on the face of the mold and the corner lines and distortion due to rolling. The central zone of freezing is quite distinct. It might be likened to the trunk of a square tree with outer shell or sap wood and inner core or pith wood. This condition is shown in Fig. 9. A second example, illustrating the persistance of grain and the effect of different macro-etching agents, consists of a section of splice bar about 4 inches long. One end of this section was etched with sulphuric acid, Fig. 10, the other end of the same piece was etched with Humphrey's reagent, Fig. 11.

The grain of the metal shows the distortion which the original ingot had received. A longitudinal section would show a marked fibrous appearance. The Humphrey's reagent has left a high phosphorus area standing in relief in the center of the section, while the sulphuric acid etch has removed this same area and left a deep cavity in the center of the section.

Fig. 12 is a macrograph of the grain of a 0.50 per cent carbon basic steel ingot reduced to one half full size. Fig. 13 shows the same material magnified 3.6 times. The grain which is so obvious in all of these macrographs persists through all normal working and treating of the steels. It represents an important characteristic of steels, a characteristic which is not considered as carefully as it should be by our manufacturers and metallurgists.

These examples all illustrate the well known fact that iron and steel

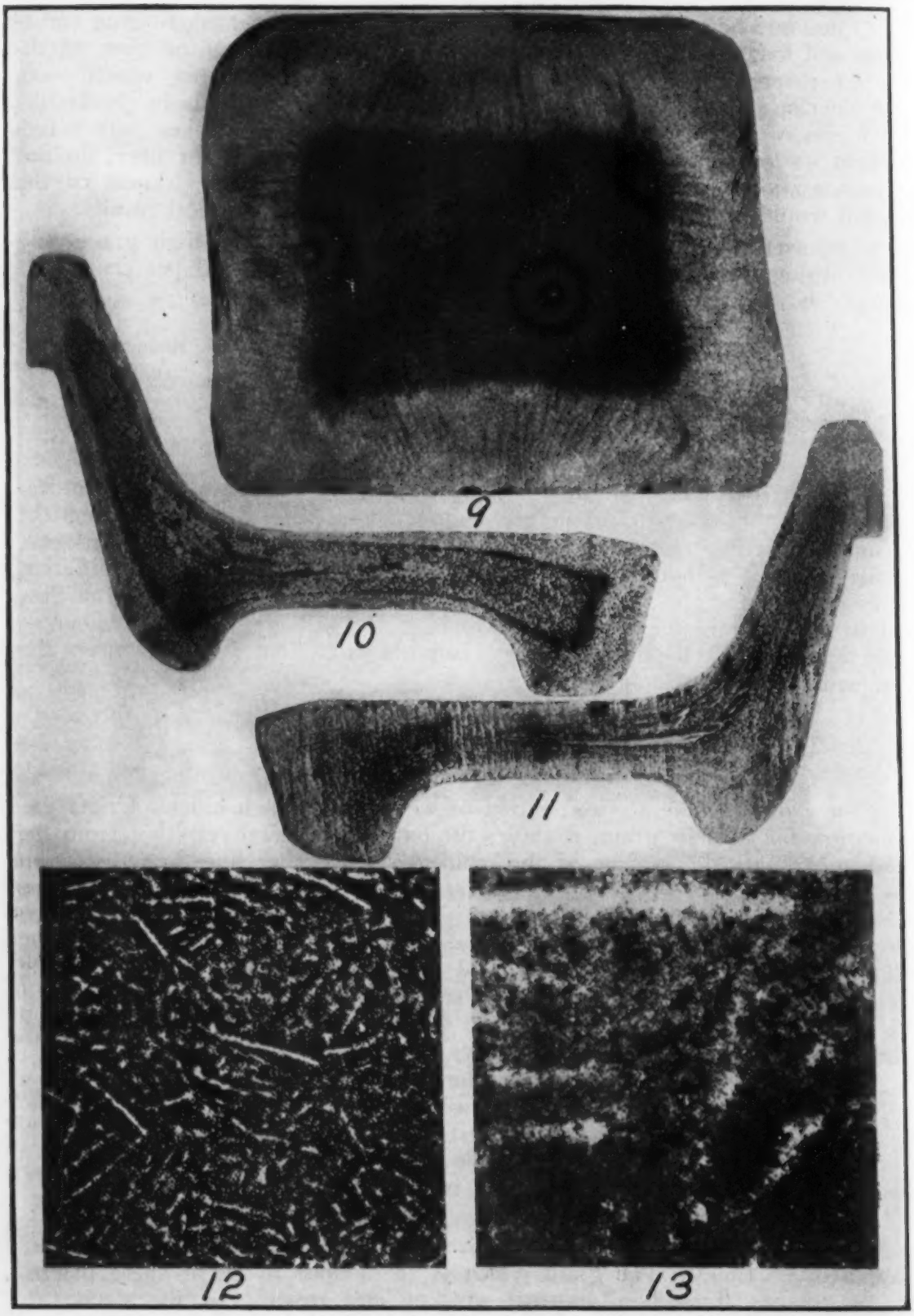

Fig. 9—Macrostructure of a 4 x 4 billet showing outer ring of metal resulting from the dentritic growth on the face of the mold and the corner lines and distortion due to rolling. The central zone of freezing is not quite distinct. 3.6X. Fig. 10—A macrograph of a section of a splice about 4 inches long etched with sulphuric acid. 0.7X. Fig. 11—Macrograph of the opposite end of splice bar etched with Humphrey's reagent leaving a high phosphorus area standing in relief in the center of the section. The sulphuric etch has removed this area and left a cavity. 0.7X. Fig. 12—Macrograph of 0.50 carbon basic steel ingot. 0.5X. Fig. 13—Macrograph of same specimen magnified 3.6X.

possesses structural characteristics and physical properties which are not uniform in all directions; characteristics which are the result of the fiber or grain of the material. A critical study by means of impact tests, fatigue tests, transverse tensile tests, and macro-etching of any class of iron and steel would show marked variations in properties of the material resulting from variations in methods of manufacture. The chemical and micrographic conditions might not vary, but the fiber of the material, the result of melting, casting, and working conditions would vary greatly. It is desired to emphasize the fact that fiber has a marked influence on the performance of metals and that chemical, micrographic, or longitudinal tensile tests do not indicate the character of the grain or fiber of the material. The fiber or grain of steel is the result of three main factors or classes of conditions as previously stated. It is desired to make a brief review of these three factors or causes which give to the steel a heterogeneity which persists through all treatments and which greatly influences its performance in service, which causes differences in the steels equal in magnitude and character to the differences which exist between a piece of hemlock and a piece of hickory.

The condition of the molten metal has great influence on the fiber of the finished steel. The temperature of the metal influences the rate of freezing and size of dendrites. The degree of oxidation has much to do with the amount of nonmetallic inclusions which collect between the branches of the dendrites. A steel, which has been deoxidized in the ladle is like muddy water; all through the molten mass the reactions between deoxidizer and oxygen are going on giving nonmetallic mud which is trapped by the freezing metal and gives grain just as slag does in wrought iron. Gas in solution or trapped in the metal probably has some influence. The conditions of solidification regulate the size and character of grain through the phenomena of selective freezing. This phenomena gives the well known segregation at the top of the ingot, and it gives a similar segregation throughout the entire mass of the metal. Each crystal or dendrite as it forms follows the laws of selective freezing and results in a secondary or minor segregation or chemical heterogeneity throughout the mass of steel. A heterogeneity which persists through all heat and mechanical treatment. A heterogeneity, which, coupled with the nonmetallic inclusions, give the fiber or grain to steel. Micrograph Fig. 12 shows the character of this segregation. The phenomena of selective freezing is not difficult to understand, but attention should be directed to the fact that there is a secondary or reverse segregation which takes place in steel after it has solidified. This secondary segregation results in ferrite lines appearing in the finished steel at the places, where, at time of solidification the carbon was highest. This reverse segregation is sometimes overlooked in reading back from the macrostructure to the cause of fiber or of banding in steel.

The flow of metal from working, merely distorts the fiber or grain which formed when the metal solidified. There is nothing mysterious about this phenomena, but it is highly important in designing the different stages in the forming of metal articles. Sharp angles are always avoided in finished shapes and fillets are used freely but we are apt to overlook the fact that quick changes or distortions in fiber are just as serious. An additional operation in forging a crank shaft may ease off the fiber around a quick change in direction and mean the difference between a good shaft and a bad shaft. The macrostructure should be studied for every stage in the forging of a part before the final method of forging is adopted. Often great improvements can be made by slight changes in die design.

Discussion of Prof. McIntosh's Paper

MR. E. J. JANITZKY (Chicago): I would like to call attention to an article by Dr. E. Kothny of Traisen, Austria, which appeared on page 677, Stahl und Eisen, May 20, 1920, which deals with a specification for airplane crankshafts that required beside the usual statical test, a fracture test which had to reveal a fibrous texture. The test specimens had to show the following physical properties for acceptance:

	Elastic Limit	Tensile Strength per Square	Elongation	Reduction of Area	Notch Impact Meter
	Kilograms	Millimeter			Kilograms
Longitudinal	95/110	105/120	7%	45%	8.0
Transverse	95/110	105/120	4%	15%	2.5

The following chemistry was found to give these requirements:

Carbon	Manganese	Silicon	Nickel	Chromium
0.20%	0.40—0.60%	0.2—0.3%	4.0—4.5%	1.0—1.5%

The tests were taken in the following manner: Two test specimens were to be cut from each shaft, roughly forged, machined and used for the tensile and nick tests. The remainder of these pieces were to be nicked vertical to the longitudinal axis and broken under the press in order to expose the fracture in a larger area. The nicked tests of the longitudinal pieces and the fractures of the other samples had to show a fibrous structure and a good tendency to flow.

In the manufacture of this steel in consecutive heats it was revealed that although the tensile tests were satisfactory the fibrous fracture could not be obtained. An investigation was therefore conducted.

The results of this investigation were startling. Through a serious of careful tests, the working conditions were observed and determined for the manufacture of chrome nickel steel in the electric arc furnace for airplane shafts.

The following conclusions were derived:

1. Only high grade material should be charged.

2. Even when using the purest base, two oxidizing slags previous to the refining slag must be worked in order to obtain the fibrous structure in the heat treated state.

3. The method of adding the deoxidizers and the ferrochrome has no influence on the fracture.

4. The temperature of the ingot mold and the method of pouring (top and bottom) have no influence either.

5. A long duration of solidification which can be due to hot pouring or the use of sand molds produces a steel which shows a strong transverse fiber in the worked state.

6. A manganese content exceeding 0.80 per cent makes the structure granular in the heat treated state.

It is also noteworthy that metallographic examination did not differentiate between a granular or fibrous fracture.

Point 2 of the above conclusions invites the investigation of metallurgists.

Point 5 seems to give the answer to Professor McIntosh's paper.

PROF. McINTOSH: I am not sure I caught all the points you present, but I think I have some of them and I am glad you mentioned them because they bring out the thing that I spoke about when I started; that is,

that we are lacking in a specific nomenclature to cover what we are talking about.

We speak of a woody fracture, and when we speak of that we refer to a woody fracture in the test piece, I take it. That is not what I am trying to point out. That is a well defined phenomena, and my analogy of hickory and hemlock probably coupled up with your woody fracture has caused a certain amount of confusion. I am not speaking of fractures at all in this work. I am speaking of fiber in steel, which depends on the conditions of melting and casting the steel. You might get a fibrous fracture or you might not, but I still maintain that all steel you get will have these characteristics which I have called fiber for lack of a better name, which I have suggested might be called grain, and I foresaw the conflict due to the difference between the microscopic structure and the macroscopic structure.

You spoke of crank shafts. I saw a very interesting application of this study, of the kind of fiber I am trying to talk about, in the manufacture of a crank shaft by a well known automobile maker. They had trouble with a breaking off where the shaft joined the disk at the end of the crank. A study of the kind of fiber that I am talking about showed that the grain of the steel, or the fiber, had been very much disturbed when it made that sharp change from the straight round shaft to the circular disk; just as if you abuse a piece of wood, and wreck the fibers, you cause a weakness. They changed the method of making crank shafts, put in an additional step to ease the flow of the metal from shaft to disk and those troubles disappeared.

I have seen the same thing in the manufacture of cartridge cases, which is a very severe process as far as the flow of metal is concerned. By studying the grain or fiber of that material and changing the punches and dies so that the material flowed gradually and wasn't abused in any of the operations by making a sudden jump in the grain of the metal which could not be remedied by heat treatment, it was possible to make a superior case.

I have seen the same thing in shell forgings. You remember the button, that, under certain conditions, used to fall out. They were afraid of prematures as the result of it. That button was merely due to abusing the kind of fiber that I am talking about. That is, with improperly designed punches and dies, from the very start, there was a bit of dead metal ahead of the punch, and off to both sides of that was metal that you flowed excessively, so that you had a cone of rupture between the material that was flowing and the dead metal in front of the punch. By developing proper shaped punches that source of danger was eliminated.

MR. N. B. HOFFMAN (Pittsburgh): Is there any formula you can use in a percentage reduction, to completely remove the dendritic structure in a carbon steel?

PROF. McINTOSH: You can't remove it at all. Your formula of reduction merely means how much you are going to draw it out. The work of Charpy and others has shown, for example, that excessive reduction reduces the transverse test values of steel. That is because it introduces more of these lines of weakness. I think one of the reasons that a crucible steel performs better than a similar grade of steel in larger ingots is due to the fact that with a smaller ingot you get small dendritic growth, and fine fiber; but I am still convinced that you will get fiber or something corresponding to it. It may not be clearly visible in all steel. But I think in order to really get rid of fiber you will have to go back and change the laws of nature which govern selective freezing.

MR. HOFFMAN: Then a larger ingot would take more reduction than a smaller ingot?

PROF. McINTOSH: There are so many factors in a thing like that that I would hate to commit myself. I wouldn't attempt to make a general statement on a thing of that kind.

MR. J. M. LESSELLS (Pittsburgh): I would like to ask if you are putting forth the theory of trying to get rid of the fiber? The more fiber you have the higher reducing properties you are going to have.

PROF. McINTOSH: If you take out the fiber from a piece of hickory or reduce the amount of fiber, you might get a wood like boxwood, but it wouldn't do the work that hickory does. No, I am not making an attempt to say that the elimination of fiber would give you better material, but I am attempting to say that fiber is of prime importance in the performance of the material. I don't even say it is desirable. I wasn't attempting to say we should abandon chemical analysis or abandon microscopic examination. But I am trying to say that macroscopic examination is of prime importance and is a subject we have neglected, and that when a heat treater is compelled to get results with steel in which his only specification is chemical analysis, it is a case of taxation without representation.

MR. HOFFMAN (Pittsburgh): I believe you are pretty well on the way to beating nature to it when you spheroidize a square ingot. You eliminate your fiber structure to a great extent. You almost eliminated your fibrous material by spheroidizing.

PROF. McINTOSH: I don't think so, although in that particular zone the fiber would not be as marked as in the central zone. But that outer zone, just as in your ferrite here, would probably have differences in phosphorus content which would not disappear if spheroidized. I am inclined to think that the condition of gas in the steel has something to do with it. Any steel will have from 5 to 15 times its own volume of gas in it. That is about all we do know, but the steel that we have here is a basic steel, very low in phosphorus, and yet I think you will find that both zones in this steel contain fibre. In this very crude piece of etching you can see elements of fiber out in that outer zone. Of course when you make that into a rivet or telegraph wire or any structure, you have two combinations of fiber that show up.

MR. A. M. COX (Pittsburgh): When the company I was recently connected with first started the manufacture of motor pinions for street railways, they used bar stock. Upon deep etching for macrostructure practically each strain line could be traced from one end to the other parallel to the bar length.

The next step in the procedure was to go to upset forgings on account of the teeth breaking out easily when using bar stock. That helped some because the fiber or strain lines seemed to mesh in between, past each other and upset at the top and bottom due to the upsetting process of manufacture. The upsetting was used. So that, if a tooth should happen to break out, it would cause a breaking of fiber lines which would give you a stronger resisting tooth than possible with the forged steel bar.

About a year ago we tried first the upsetting and subsequent drop forging. We got the upset pinion results combined with the drop forging, which caused a flow of the fiber lines so that in order for a tooth to break out it had to cut more fiber lines or overcome greater resistance. The breakage has been practically eliminated by using the upset and drop-forged pinion. That is along the line of making use of the fiber lines in steel.

MR. E. E. THUM (New York): I would like to ask Professor McIntosh if he has been able to fix in his own mind the border line up to which nonmetallic inclusions are desirable as causes of fiber, and the other step beyond the danger line where they are undesirable as causes of woody fractures. I assume from your remarks that perfectly homogeneous metal is not desirable.

PROF. McINTOSH: I didn't mean to convey that idea if I gave it. I have not exactly made an effort to formulate what you have in mind. I have always been under the impression that in steel, nonmetallic inclusions represented something abnormal or undesirable. It is something like the imperfections of a human being—the fewer we have the better off we are, but none of us are ever perfect.

With fiber in steel, I think that nonmetallic inclusions should be only minor factors. Does that cover what you have in mind? I didn't intend to convey that it was my idea that fiber in steel is the result of nonmetallic conclusions. It may have something to do with it, but I didn't intend to convey the impression that you seem to have.

MR. THUM: Fiber is due to the nonuniform distribution of carbon rather than the presence of insoluble oxides such as result from deoxidizing operations in the steel furnace or ladle?

PROF. McINTOSH: Yes, as far as I know.

So many people confuse segregation as detected by the chemist with the segregation which gives fibre. If we had some good way of differentiating between microsegregation and macrosegregation such as we have in the structure, it would be good. That is my idea, and it is fairly well founded, that fiber is the result of this segregation which could not be detected by chemical analysis; it occurs all through the mass as the result of selective freezing, rather than the segregation which we detect by chemical analysis.

MR. ARTHUR GREEN (Philadelphia): Professor McIntosh, do you believe that, giving ourselves over to the belief that fiber is in steel in this shape the fiber becomes more developed in the working of that steel? Does it become more accentuated?

PROF. McINTOSH: It is only by working that you distort it. For example, here you might work down to a ½ inch round, and the fiber on cross section of the piece would not be very noticeable. It would merely represent little differences like that. But that extreme reduction in elongation would mean that longitudinally you would have drawn these chemical irregularities out and made them into very long fiber.

MR. GREEN: Suppose you have done that and put the piece of steel to work, is it natural for the lines to be further accentuated? The reason I ask that is that I have been noticing on one of the piston arms that we have in the mill, that there has developed a beautiful fiber structure. It is a connecting arm between the cog and the piston itself and represents roughly about 8 inches of material one way and 3 inches the other. The fibrous condition seems to grow, although I have made no measurements. I am wondering whether this fibrous condition is one that does accentuate itself.

PROF. McINTOSH: That is an interesting case. It is one that I wouldn't attempt to answer. I am doing, as I said, a lot of work on fatigue and we noticed that steels which were banded with well defined longitudinal bands of ferrite, gave a rather poor life. Of course what probably happens is that those bands represent material much weaker than the steel as a whole. Cold work sets up and goes on, you start a fatigue failure in one of the bands, and it progresses across the piece.

It probably is a banded steel and has ghost lines, and perhaps there is a little cold work leading up to failure by fatigue, and a tendency to corrode resulting from the cold work makes the lines visible.

MR. H. C. KNERR (Philadelphia): I would like to ask whether you consider that incompletely killed or gassy steel has anything to do with this question of "fiber."

PROF. McINTOSH: I was afraid somebody would get into that field and ask about the difference between effervescent steel and killed steel. I don't really know what it has to do with it. I would like very much to, though.

MR. W. B. CROWE (Pittsburgh): I would like to take the liberty of adding some of my experience with fiber to what Prof. McIntosh has already given.

I wondered, the first three or four years of my experience, just what fiber was, and was unable to arrive at any definite conclusions. The term fiber appeared to describe two widely differing properties in steel, one representing flow lines of hot worked steel as revealed by the macro-etch, the other a characterization applied to the fracture of very tough steel. I will take up the latter application of the term to begin with.

A very tough steel permits a pronounced grain distortion at the points of rupture, and the more pronounced this tendency, the greater will become the shock resisting properties, assuming the tensile and elastic strength to be a constant.

I have taken specimens from the so-called fibrous steels having had different treatments. The tensile and elastic properties were practically the same, and yet in many cases the fractures showing fine crystalline structure had a much higher percentage elongation and reduction than many of the specimens which showed a fibrous fracture. And yet experience has shown that the latter stood a much better dynamic test especially under high velocity of impact. The property therefore which a fibrous fracture appears to indicate is toughness rather than ductility. And this property is the result of the combination of correct treatment applied to the correct type of steel.

That mass increases the difficulty of obtaining fiber I will give an example: Two types of steel 3 inches thick were treated to produce a fibrous fracture. The specimens were increased in thickness to more than a foot. One type continued to show as good a fibrous fracture as previously described with 3 inch section. The other type persistently refused to develop a fibrous fracture.

These large fractures produced by a 12000 ton press showed much different characteristics. The one which was fibrous appeared to tear rather than break, and the operation was done so quietly that one would not know it had been completed if he were not watching closely; but in the other case there is a decided flexure, a sudden crash which may be heard nearly a thousand feet away, and a jar which one might think had wrecked the press. In both cases the speed of depression of the ram was the same.

So it seems to me that the fiber as revealed by fracture is an entirely different property from the fibrous internal structure of the metal, a property which is contrasted by composition combined with a definite treatment.

Regarding fiber as revealed by the macro-etch, I have found that steel which had not yet been rolled or forged did not develop a fibrous etch, that this type of fiber was an arrangement of sonims into definite flow lines, having the appearance of fiber, these becoming a fixture immovable by heat treatment. It is a question whether such a condition is desirable.

FACTORS INFLUENCING MASS HEAT TREATMENT

By W. B. Crowe

OF THE numerous factors, influencing mass heat treatment, the majority of them occur before the actual operation of heat treatment itself. Mechanical design is an important factor of influence and in a great measure controls the character of the heat treatment to be employed. It may render the process of treating extremely difficult, if not unsafe, and may even make satisfactory heat treatment impossible. There are many cases on record where failures which were at first attributed to inferior heat treatment were traced directly to faulty design, Since the advent of high test alloy steels into more general use, there has been a tendency on the part of designers to over reduce the mass of metal in a given component with the result that failure occurs in service. It is quite true that one of the prime objections in using the higher priced steels is the reduction of weight, yet there are cases where due to the nature of the stresses involved, such as torsional and bending stresses, a considerable reduction of mass cannot be made without introducing serious mechanical faults. Where such is the case and section is the controlling factor with reference to amplitude of flexure or torsion, the cheaper plain carbon steels with their usual physical properties may be used satisfactorily. There are cases, of course, where the most highly developed properties attainable are required, which naturally introduces the factor of composition as it influences the physical properties of large masses undergoing heat treatment.

Irrespective of the quality of the steel, its fabrication or subsequent heat treatment, unless the chemical composition very closely approaches the specifications established, the ultimate results will be more or less undesirable. All other fields of investigation in steel are small in comparison with the field of exploration in composition. The cost of evolving a new composition involves a very considerable amount of time and money. An entire melt is required for each new compositional experiment, each of which may take a thousand fabrication or heat treating experiments with the compositional problem still unsolved. As mass dimensions are increased the effect of composition becomes more pronounced. Specimens of laboratory dimensions may be selected from various types of steel ranging from the simplest to the very complex, which, when water quenched may show very similar physical properties. If the mass of these representative steels is very considerably increased, the physical properties will be found to have diverged greatly. For example, experiments made on 0.55 per cent plain carbon steel, 0.45 per cent carbon, chrome vanadium steel, a 0.45 per cent carbon, nickle chrome steel, a 0.40 per cent carbon, chrome molybdenum steel and a 0.47 per cent carbon, nickel chrome molybdenum steel. Specimens one inch in diameter were water quenched from experimentally predetermined temperatures. All specimens showed a sclerosocope hardness of 90 to 95 and with a Brinell tensile equivalent between 300,000 and 325,000 pounds per square

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A paper presented at the Pittsburgh Sectional meeting, May 25-27. The author Wallace B. Crowe, is armor plate metallurgist, Homestead Steel Works, Munhall, Pa.

inch. Ground tensile tests were made from several of the specimens, but the results of check tests showed them to be so erratic that they were of little value.

Masses ranging from 12 to 13 inches in thickness, from one to several feet in width and from 5 to 20 feet in length, out of which the previous specimens had been obtained, were water quenched from tempertaures which were determined as the result of much previous experimentation. Test coupons were then broken from these large specimens, presenting a fracture about 1½ times the thickness of the piece from its end, and practically the same or a greater distance from the edge. The fractures presented a vastly different appearance when compared, as might be expected. These may be classified as follows:

Type of Steel	Appearance of Fracture
Plain Carbon	Fine granular near surface gradually coarsening to medium fine grain near center.
Nickel-Chromium Chromium-Vanadium	Porcelainic appearance 3 to 4 inches from surfaces.
Nickel-Chromium-Molybdenum	Semi-porcelainic internal appearance.
Chromium-Molybdenum	Similar to plain carbon steel although somewhat coarser.

Further examination revealed that those steels showing porcelainic or semi-porcelainic fractures were untoolable at any location, the toolable limits of these steels having been equivalent to 70-72 scleroscope. The plain carbon steel and the chrome molybdenum steels were each toolable at any location, the latter being the more so The most important characteristic observed was, that the plain carbon steel showed a greater falling off in hardness between the surface and the center than did the chrome molybdenum steel, the former showing a Brinell tensile equivalent of 180,000 to 120,000 pounds per square inch, while the latter showed 140,000 to 130,000 pounds per square inch.

The chrome molybdenum steel showing unusually low hardening properties in mass for an 820 degree Cent. quench was investigated more exhaustively. Two more large specimens were quenched from 875 to 1050 degrees Cent. respectively, the first having been quenched from 820 degrees Cent. The three sets of fractures were so similar as to be indistinguishable. Hollow-drill tests were drilled with ease through the thickness of each, and were Brinelled each inch of length of test bar, showing a variation of not greater than 15,000 pounds per square inch. Tensile bars were drilled longitudinally, parallel with and four inches from the surfaces. The results were surprisingly close, the tensile strength, the elastic limit and elongation varying no more than 2½ per cent and checking the previous Brinell tests. The actual tensile strength ranged from 133,500 to 137,000 pounds per square inch. Specimens taken from near the axes of the masses, and examined under the microscope, revealed that the masses which had the deepest chill showed the finest microstructure, after a drawback heat treatment.

The point which these experiments emphasize is that little relation exists between the physical properties of small and large masses, and that the heat treatment suitable for small specimens cannot be depended upon as a criterion for the proper treatment of large masses, except in a general way.

The large specimens above described were subsequently drawn back

at certain temperatures to produce approximately 20 per cent elongation in 2 inches and pulling tests were then made. The results of these tests showed that the outside-inside differential had practically been reduced to nil, and that the physical properties descended in about the same order as their respective chill depths, there being a great difference between the extremities of the scale. Specimens from the same types of steel were then subjected to air treatment, being air cooled from above AC3, and it was again found that those types which were susceptible to deep chill were untoolable, while those which had little or no chill after the water quench, were machineable. The untoolable specimens were drawn back to obtain approximately 20 per cent elongation in 2 inches, and their physical properties were far superior to those of the non-deep-chill type having had a water quench and a draw. Therefore, it may be necessary, in order to meet certain physical requirements, to employ those types of steel which are more susceptible to hardening. Where the mass is of such a shape as to render water quenching a hazard on the lower types of steel, the operation may be rendered far more safe by using the higher type steels with a less drastic quenching, and at the same time obtain superior physical properties.

The influence of sonims has an important bearing on the subject. It is the writer's opinion that the evil influence of sonims has been over estimated without due consideration of the nature and extent of the same. It has been his experience to examine microscopically steels which had shown excellent service tests, and which revealed considerable quantities of sonims. Previous to these examinations the writer had been very much opposed to such a condition but these service tests revealed the fact that sonims are not as detrimental as we have believed. Numerous specimens have been examined which have failed in service and which were practically free from sonims and would clearly come under the classification of clean steel. The presence of sonims therefore could not have been the cause of failure. In reviewing these investigations of sonims, the writer believes that the nature of their distribution is the important phase of the subject. Where the foreign matter is uniformly distributed in tiny particles and there is no continuety of arrangement, it has been found that the steel will usually pass normal requirements, but where the foreign matter occurs in agglomerations which would cause definite laminations and these arranged in a line of continuety, even though a large percentage of the steel appears to be clean, ordinarily a component made of such a steel could not undergo severe treatment without serious developments.

Where a highly specialized product is to be forged or rolled, and later heat treated to obtain extremely high hardness values, such as 100 to 125 sclerosocope, the steel should approach the highest degree of freedom from sonims and blowholes. Such defects may cause the rejection of the entire heat for the purpose intended.

Hot-top iron molds, having a section of 2 to 2½ times that of the ingot and preheated between 300 and 400 degrees Cent., will further improve steels susceptible to cracking.

Blowholes in nonwelding steels are quite similar to sonims in their effect on heat treatment, and after forging or rolling are almost indistinguishable from them even with the aid of the microscope. Where such conditions are known to exist the greatest care is necessary in

the heat treating operation, especially if the requirements demand a water quench. This is especially true where the sonims exist in laminations after rolling or forging. Laminations interfere with the uniform conduction of heat through the steel, which during the stage of rapid cooling is a very important consideration. High local strains are consequently set up in that region of the mass least able to withstand those strains, and where allowed to cool too slowly, may result in the immediate rupture of the piece. Where strength and toughness are required, a mild quench slightly below color may often save the piece and produce surprisingly good results. In such a case, however, an oil quench would be preferable with less internal strain being set up due to retarded cooling. Where the oil quench is not available recourse may be had to the hot water quench, the steam performing the two-fold function of heating and agitating the water.

The points discussed cover a large number of the heat treaters problems, for if the designing engineer has given due consideration to the heat treating problems, the proper composition has been selected, the steel well made and the fabrication properly executed with reference to the preheating temperature, the temperature at which it was worked, and the temperature to which it was cooled, the heat treater will find his worries very much reduced.

Assuming that the heat treating appliances are suitable, the heat treating problem resolves itself into two phases, the treatment of steels responsive to simple though perhaps drastic treatment, and the treatment of steel requiring mild complex treatment. In the majority of cases there will be a combination of these two conditions with the former predominating and where there is a similarity of the product and a large number to be treated, the modus operandi will be largely governed by the results of the first several trials. If the percentage of acceptance is high, it would be the best policy to pursue this method of treatment, resorting to a more complex treatment on that portion of the product which failed to pass test. If, on the other hand, only a small percentage passed the test on the simple, drastic treatment, it would be advisable to swing the treatment entirely to the more complex, until such a time as it might be deemed advisable to repeat the more rapid, drastic treatment with the purpose of obtaining high percentage acceptance on first treatment. Experience has shown that where possible, it is advisable to maintain a uniform, standard treatment, thereby being better able to operate on schedules which may have to be worked up to, several days in advance. By doing this, shop complications and much loss of time may be avoided.

The influence of mass on heating has been pretty thoroughly discussed during the last few years, and therefore an involved discourse on the subject will not be entered into at this time, but in passing it may be noted that there has been a tendency to underestimate rather than overestimate the importance of the duration of heating time to obtain complete saturation. Complete saturation is one of the most essential requisites toward good heat treating, and prolonged soaking is far preferable to incomplete saturation. A good empirical rule that has been found to be quite satisfactory, where the mass has a length and width several times that of the thickness, is to allow 1 hour per inch of thickness for heating to the desired temperature, and 2/3 of

an hour per inch, for saturation. Where the mass is a green casting cooled to atmospheric temperature, internal strains may exist of such magnitude that great care should be exercised in heating the first 200 or 300 degrees Cent. The character of heating should approach that of saturating to relieve internal strains and get the metal beyond the extremely brittle stage. Masses forged or rolled, while they may have as great or greater internal strains than castings, the better able to withstand those strains, owing to the mechanical refining already obtained, and the rate of heating may be somewhat more accelerated in the early stages. Shop or mill practice generally permits a rolled or forged mass to be charged for treatment before it has cooled down to the brittle range, in which case the early heating may be forced somewhat, with safety. Where the section is isometric and the length is several times that of the diameter the period of heating and saturating is about ½ the time above described for oblong cross sections. Where the 3 axes are practically equal, the time of heating and saturating is again reduced about one half. These rules are not strictly according to formula, but have been found by experience to be a safe general guide.

While the lag in heating is practically the same as the lag in cooling, the effect of lag in heating is to a great extent taken care of by the duration of saturation. The lag which occurs during accelerated cooling cannot possibly have any compensating influence corresponding to soaking in heating, and it is in this respect that the influence of mass in cooling presents a far greater problem than does the influence of mass in heating. It is for this reason that, where this lag may interfere with the internal physical properties demanded, the greatest judgment should be used in the selection of the composition least susceptible to the influence in this lag. The effects of this lag, however, may be somewhat overcome by increasing the temperature over AC3 with the increase of mass. The lag then takes place above the critical range so that in passing through the critical range the steepness of the thermal gradient of the center of mass has somewhat approached that of the exterior of the mass. This is done at the expense of the grain size, but the physical properties of the mass as a whole are superior to those where the mass is treated at the theoretically correct temperature.

Where the physical properties fail to satisfy after a quench, and drawback, and the cause appears to be a lack of grain refinement, recourse may be necessary to what has been termed a stepping-down treatment. Where the grain size is very large it will be found that the grain refinement will require an unreasonably prolonged soaking if the temperature is only slightly above AC3. It will also be found that if the temperature is raised 100 to 125 degrees Cent., the grain size temperature characteristic will be obtained quite rapidly. The grain size will be found to be much smaller than originally, but perhaps coarser than desired. If this is the case one or more intermediate treatments may be employed. The increased rate of change of grain size with the temperature is probably analogous to the cementation process in which the rate of diffusion of the carbides is much accelerated by an increase of temperature over AC3. The mass may be quenched after the various steps of heating if the material can stand it, but the general practice is to quench only the last 1 or 2 steps.

Masses of irregular section which tend to develop quenching cracks

in the thinner sections, present a problem which requires much study and experience. It is often necessary to retard the rapid cooling of the thinner section by the application of some insulating material, such as sheet asbestos, sodium silicate and asbestos compounds or even ordinary yellow clay with wire reinforcements, or any material which will more equalize the rate of cooling and reduce the local strains. The mass is generally cooled in the bath to a point, where when removed, the internal heat will reheat the surface to 125 to 350 degrees Cent., depending on the final hardness required. The mass is then ready for whatever drawback experimentation is desired.

It has been the purpose of this paper to point out some of the contributary causes of failure which should not be chargeable to poor heat treating, and to touch on some of the difficult points in the heat treatment of large masses. The writer appreciates that there is a growing co-operation between the designing engineer, the steel manufacturer and the heat treating engineer, and feels that the Amrican Society for Steel Treating and other engineering societies deserve their share of credit in working toward this end.

Discussion of Mr. Crowe's Paper

MR. GREEN (Philadelphia): The speaker made reference to quenching in hot water if oil was not available. What was the temperature of the hot water?

MR. CROWE: Approximately the boiling point. We have tried it at different temperatures. It is only a question of a short time before the water is heated to one hundred degrees. I don't believe it will produce as good results as oil but if you don't have oil it is far better.

MR. GREEN: The particular reason I asked that is that I had an experience sometime ago in going into a shop where they were quenching in cold water, and found considerable quantities of their material cracking. Then they changed to hot water, at 110 degrees, and the material seemed to have greater depth of hardness than when quenched in cold water. That was two years ago. Well, the other day, or quite recently, I was at that plant again and I asked them whether they were using warm water and they said yes, that they would not go back to cold water.

MR. CROWE: Of course it is difficult to maintain the temperature of the water constant. I am thinking of masses of twenty, thirty, forty or one hundred thousand pounds. That is what most of them do not have experience with.

I experimented with various temperatures, beginning with iced brine and every twenty degrees above up to the boiling point I found there was a tendency to get soft spots when immersed in water near the boiling point, as shown with the scleroscope and microscope.

MR. I. E. WALTON (Pittsburgh): I would like to ask Mr. Green whether he has tried cold water in comparison with hot.

MR. GREEN: This was an plates that had to be uniformly hard, and the hardness was more uniform when quenched in 110 temperature bath than when quenched in baths at temperatures around forty or fifty degrees Fahrenheit.

MR. CROWE: Well I found there was little difference between ice brine, and up to 60 degrees Cent. But as you get up toward the boiling point there was a greater tendency to develop soft spots, which may be quite serious and might spoil the mass.

MR. MORGAN (Pittsburgh): In your experience of the treatment of large masses, have you run into any instances where the shrinkage stresses developed and caused fractures, complete failures, or shattering of the steel?

MR. CROWE: Yes sir, that is almost the biggest problem we have and that is the point I brought out with reference to protections to more nearly equalize the rate of cooling. A large part of my experience has been with spraying, which is probably the most rapid cooling method known and unless due regard is taken in protecting portions cooling most rapidly, they will be cool long before the balance may be cooled down to loss of color, with the possibility of the coldest portion being ruptured. A careful study must be made of the balancing effect of protections.

DISCUSSION OF PITTSBURGH SECTIONAL MEETING PAPERS

FOUR of the six papers which were presented at the Pittsburgh Sectional Meeting held May 25-27 at the Bureau of Mines, Pittsburgh, Pa., were published in the May issue of TRANSACTIONS. The purpose of preprinting papers which are presented at either the annual convention or the sectional meetings is for the purpose of stimulating discussion, as it is realized that a large amount of valuable information is brought out through a well organized discussion. In order that members may have the opportunity of receiving papers before they are presented the policy has been adopted of publishing as many meeting papers as it is possible, prior to their presentation. This policy was in force at the time of the New York Sectional Meeting and as a result a large amount of splendid discussion followed the papers presented. The same is equally true of the discussion which followed the presentation of the Pittsburgh papers.

The discussions of Prof. F. F. McIntosh's paper entitled "Fiber in Iron and Steel" is appended to his paper which appears in this issue of TRANSACTIONS. Likewise the discussion of W. B. Crowe's paper entitled "Factors Influencing Mass Heat Treatment" is published in this issue of TRANSACTIONS with its discussion appended.

The discussions which follow are in the order of their presentation at the meeting. Each of these papers may be found in the May issue of TRANSACTIONS. The titles of the papers which are discussed in the following pages are:

"A Discussion of Impact Testing Methods and the Results Obtained."—by John M. Lessells.

"The Abrasive Qualities of Plain Carbon and Alloy Steels."—by A. M. Cox.

"The Importance of the Proper Heating and Cooling of Steel."—by John A. Succop.

"The Change in Dimensions of High Speed Steels in Heat Treatment."—by Marcus A. Grossmann.

Discussion of Mr. Lessells' Paper

MR. E. E. THUM (New York): A great many of us will not disagree that impact testing will become of considerable importance, if it is not already so, but there are yet some who fail to see that the impact test indicates infallibly variations in quality of the metal. In other words, many American metallurgists will decline to admit that the impact test is competent and reliable. Does the impact test do anything that can be depended upon? Are the variations which it shows due to actual variations in the metal, or to variations in the action of the testing machine or to a combination of both? Mr. Lessells has just shown a curve indicating impact strength of a certain steel after various heat treatments. That curve showed a peculiar drop at a certain temperature range, corresponding to "notched brittleness." Is notched brittleness anything, and if it is something, what is it?

There is a general tendency in the art of testing materials to get away from "omnibus" tests in favor of tests which determine one particular property. In other words, we seldom take a particular casting or forging and bend it under a hydraulic press, and observe its action. We would much rather have test bars cast from such a fabricated piece and pull them apart in a testing machine. In consequence, when testing the strength of rivets, we seldom rivet up a joint and pull it apart. We depend rather on getting our information as to quality from simple shear or tension specimens, and then try to translate those results into what we may fairly expect of the performance of a riveted joint. It seems to me that the impact test is a reversion to the omnibus test, since no one is quite sure of the nature of the resulting action when a notched piece of metal is given an overpowering blow, causing it to break in an infinitesimal time.

Furthermore, there is yet no general agreement as to the proper way to make the test. The Frenchmen will tell us how good the Charpy test is, and the Englishman will tell us how good the Izod test is. Some American metallurgists are free to tell you how bad they both are! Apparently a great need is accurate information, or wider publication of such information as exists, on how closely a well designed impact machine can reproduce results on material which we are sure is quite uniform by knowing the details of its manufacture and by exhaustive testing in other ways; and on the other hand, how the same test works on material which is known to be non-uniform. Suppose, for instance, that we have a considerable volume of most excellent, uniform metal, and we test this metal in various directions by various machines. Now if the curves which one might draw against any particular property of this metal plotted as a straight line, or nearly so, and the impact results, (when made by several accepted machines) would parallel each other, and would do so, not once but every time, then the objectors would have to admit that the impact test as perfored in the correct way is a good test. If, however, the impact curves would not parallel, but would cross each other and wander around at random, then it would seem to me that it is up to the proponents of impact testing to explain why these various methods do not agree among themselves. It might even be that one steel would be passed if tested by a certain machine in impact, while another impact machine would reject that same steel.

I have in mind some results which have been recently published by the Joint Committee on the influence of sulphur and phosphorus in steel. This committee was appointed by the American Society for Testing Materials,

and contains representatives of various steel-making and steel-using organizations. It was convened primarily to discover whether war time limits of sulphur and phosphorus could be safely retained.

Their first report covers the effect of sulphur in rivet steel. Fourteen heats of steel were made, under close observation, by the Carnegie Steel Company, in a 75-ton basic open-hearth furnace. The composition of the steel was held quite constant except for sulphur, which varied in each one, ranging from 0.02 per cent to 0.18 per cent. Altogether over 5000 physical tests and 1000 chemical analyses were made, and in general the evidence is that the material as received from the mill was uniform and first-class in every respect. These steels were sent to the investigators in the form of one-inch rivet bars and one-inch slabs. They were tested as they were received, after an anneal at 940 degrees Cent. for half an hour (cooled in the furnace) and thirdly, after a quench from the same heat. Tests were made at the Watertown Arsenal and at the Annapolis Naval Engineering Experiment Station.

In general the reports from the two different laboratories agreed quite well. The ordinary tensile test showed that sulphur had very little influence. In other words, when plotting tensile strength, yield point, elongation, etc., against sulphur content, the curves were practically horizontal, and individual heats varied but little from the median line. From all tests other than the impact test, the material was shown to be extremely good, and it undoubtedly was uniform. As before mentioned, these physical tests all showed that sulphur had practically no influence within the limits of 2 points and 18 points.

Now let us look at the impact figures, and see whether they agree among themselves, or agree with the fact that chemical analyses and other physical tests lead us to believe that we are working on uniform metal—that is, metal as uniform as we can reasonably expect tonnage material to be at the present time.

Fig. 1 shows impact tests on the bars as received. The Izod test shows that out to a little beyond 6 points the impact strength is 115 foot pounds or better, but with increase of sulphur to 0.18 per cent it lowers to 80 foot pounds. In other words, there is apparently a sharp reduction in Izod impact as sulphur goes beyond 6 points. The Charpy test on the same bars shows practically the same thing. It should be noted that each point on these curves represent the average of 16 tests made by quite competent investigators. However, there is a third curve showing the properties as determined at Annapolis by a method called "impact shear" where an unnotched rectangular bar is broken. Eight tests were made on each heat. The point is clearly brought out by these curves that impact shear is 40 foot pounds for low sulphur, and remains at that figure *despite increasing sulphur.*

Fig. 2 shows impact tests on rivet bars after annealing at 940 degrees Cent. Note again that the impact shear curve is practically horizontal and has not been lowered very much. Also note that the Izod values, which before annealing were up beyond 110 foot pounds dropped off to about 35 foot pounds. Now we don't ordinarily expect a short anneal, at a moderate temperature, to cause a great deal of brittleness, and yet here is a test, which is supposed to give a definite measure of toughness, showing a tremendous increase in brittleness *after a heat treatment which should ordinarily toughen.* Not only is the Izod impact down 50 or 60 per cent, but the Charpy values are down 80 per cent. Also note that the Charpy curve is now practically horizontal. Furthermore, note how erratic the Izod tests have become. They

do not seem to parallel variations shown in either of the other curves. Especially heat T runs up to about 66 foot pounds for no apparent reason. Furthermore, at heat J, the Izod curve has a peak and the Charpy curve has a slight valley. Thus the correspondence of these curves is very poor.

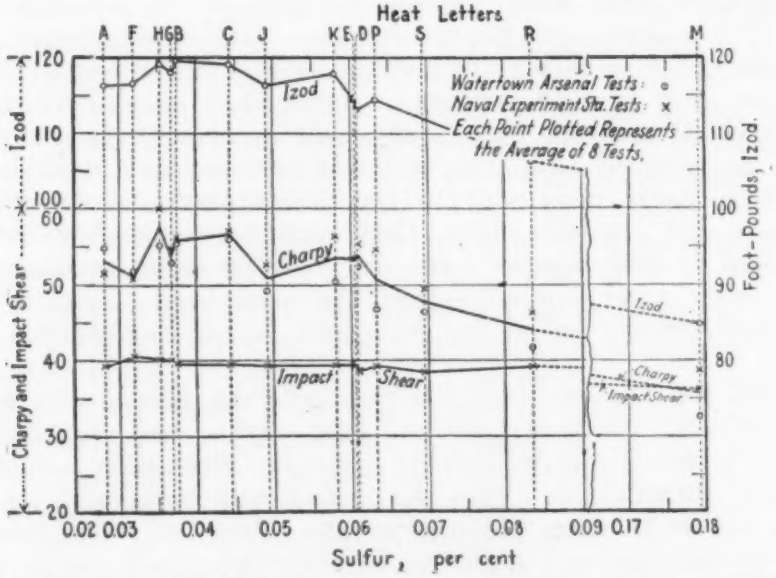

Fig. 1—Impact tests made by Charpy and Izod machines on bars as received.

Fig. 3 shows the rivet bars after quenching from 940 degrees Cent. This heat treatment actually raises the impact value—it is rather a new idea that quenching increases toughness! The Izod results again are erratic, there is a pronounced dropping off, however, at 6 points of sulphur, as was

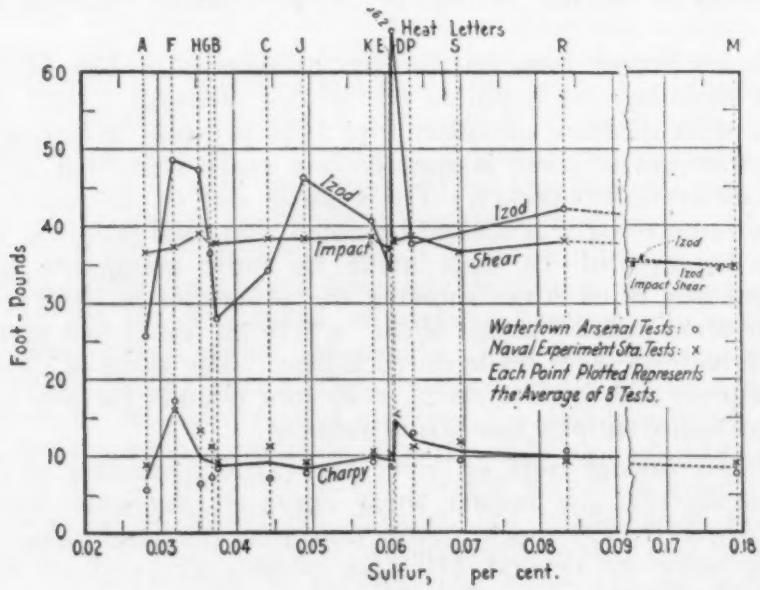

Fig. 2—Impact tests on Rivet bars after annealing.

noted in the bars as received. Impact shear for the third time is horizontal. Charpy results drop off with increasing sulphur. Altogether there is very little parallelism in the curves.

Fig. 4 shows the same steel rolled to slabs one inch thick. From these slabs impact specimens were cut from edge to edge. In one case the hammer

swung parallel to the edge of the slab, and in the other case perpendicular to the flat surface of the slab. However, in both cases the specimen was broken parallel to the "grain" rather than across the "grain." In other words, you can hit against either surface of an impact bar cut across a flat slab, but

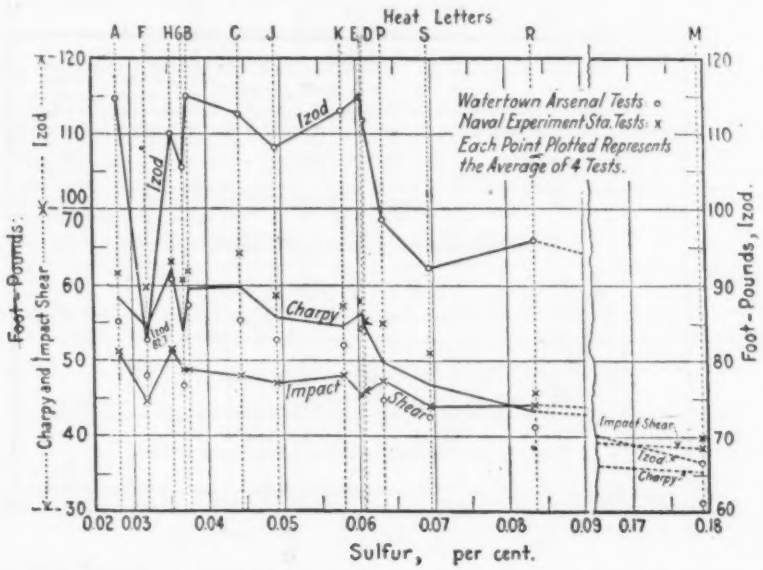

Fig. 3—Impact tests on Rivet bars after quenching from 940 degrees Cent.

in any case you will be breaking the specimen with the fibers. Now it would seem that the values in these two cases should be fairly close. In any event if one particular heat shows high impact in one direction in the Izod test, it should also show high impact in the same direction in the Charpy test.

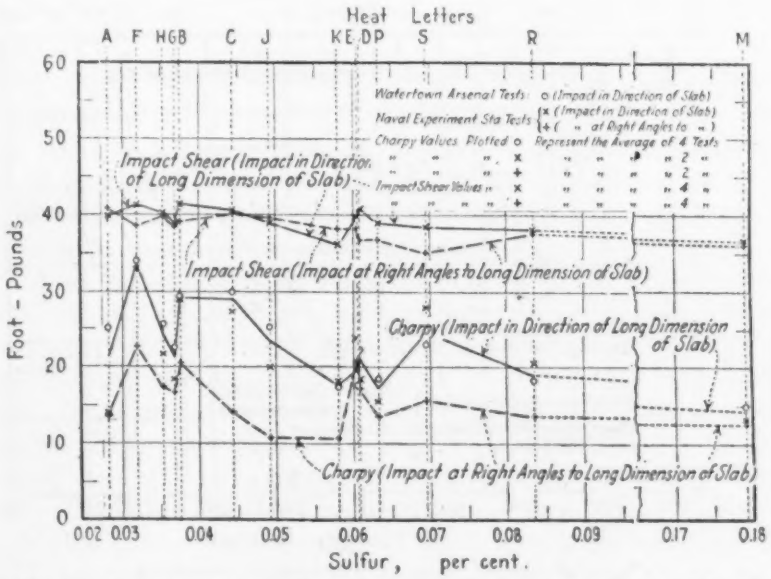
Heat Letters
A F HGB C J K E D P S R M
Watertown Arsenal Tests: o (Impact in Direction of Slab)
Naval Experiment Sta Tests (x (Impact in Direction of Slab)
(+ (" at Right Angles to ")
Charpy Values Plotted o Represent the Average of 4 Tests
Impact Shear Values " x " " " " " 2 "
" " " " + " " " " 2 "
" " " " x " " " " 4 "
" " " " + " " " " 4 "
Impact Shear (Impact in Direction of Long Dimension of Slab)
Impact Shear (Impact at Right Angles to Long Dimension of Slab)
Charpy (Impact in Direction of Long Dimension of Slab)
Charpy (Impact at Right Angles to Long Dimension of Slab)
Foot - Pounds
Sulfur, per cent.

Fig. 4—Impact tests on Rivet steel rolled into slabs 1 inch thick.

As a matter of fact, the impact shear curves cross each other several times, whereas the Charpy curves drop off slightly with increasing sulphur, but they are very much more nearly parallel—that is to say, the peaks of the two curves correspond, and the valleys to the valleys.

Fig. 5 shows the tests made on the slabs after annealing 30 minutes at

940 degrees Cent., and cooling in the furnace. Comparison with Fig. 4 will show that the Charpy results have again been very materially lowered, whereas the impact shear is practically the same. As before the curves cross each

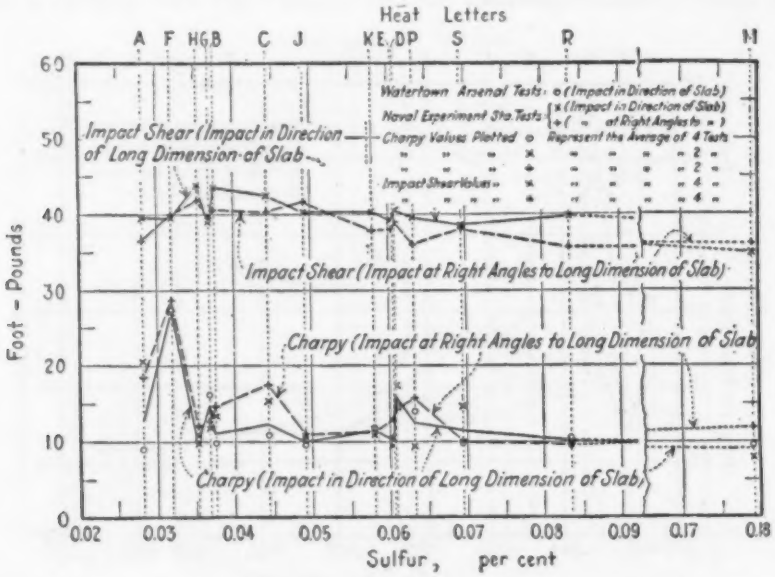
Heat Letters
A F HGB C J KE DP S R M
Foot - Pounds
Sulfur, per cent
Impact Shear (Impact in Direction of Long Dimension of Slab)
Impact Shear (Impact at Right Angles to Long Dimension of Slab)
Charpy (Impact at Right Angles to Long Dimension of Slab)
Charpy (Impact in Direction of Long Dimension of Slab)

Fig. 5—Impact tests on slabs after annealing 30 minutes at 940 degrees Cent.

other somewhat at random, showing that there is very little correspondence in whatever it is that is shown by these two impact tests.

Fig. 6 shows the results on testing slabs after they have been quenched. The results are extremely confused.

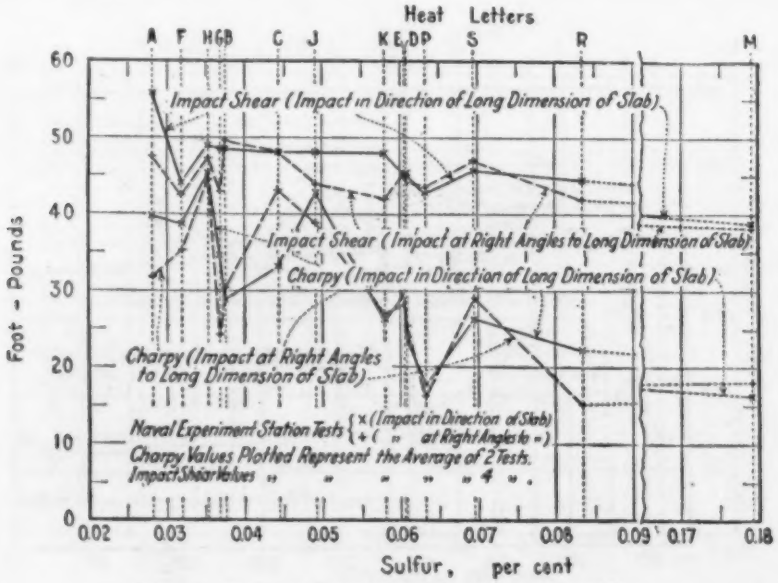
Heat Letters
A F HGB C J KE DP S R M
Foot - Pounds
Sulfur, per cent
Impact Shear (Impact in Direction of Long Dimension of Slab)
Impact Shear (Impact at Right Angles to Long Dimension of Slab)
Charpy (Impact in Direction of Long Dimension of Slab)
Charpy (Impact at Right Angles to Long Dimension of Slab)
Naval Experiment Station Tests
Charpy Values Plotted Represent the Average of 2 Tests.
Impact Shear Values " " " " 4 " .

Fig. 6—Impact tests on slabs after quenching.

Table I shows some numerical values which have been scaled as well as could be done from the figures, after sketching in a median line which seemed to fit the observed facts. In general the table shows what has been said before, namely, that impact shear seems to be independent of sulphur and fiber in the bar as received. To a certain extent impact shear is also independent of heat treatment; a variation of only a few foot pounds is ob-

served after annealing or quenching. Izod tests were made only on the rivet bars, but you can observe a tremendous drop after annealing, a loss which was more than recovered after quenching. Question marks on the figures mean that the curves are so very jagged that one can estimate what the figure is no closer than four or five units. A most peculiar thing about the Charpy test is that if you break a slab after quenching it is stronger perpendicular to the rolling than parallel to the rolling. After annealing the relation is reversed.

Altogether the results of this very extended and extremely remarkable investigation indicate to my mind that the proponents of the impact test

TABLE I—IMPACT TESTS

	1-In. Rivet Bar; Broken Across the Fiber			5¼ x 1-In. Flats, Broken With the Fiber Impact Parallel to Rolling			Impact Perpendicular to Rolling		
As received	0.03S	0.06S	0.10S	0.03S	0.06S	0.10S	0.03S	0.06S	0.10S
Izod	117	114	103	.....	.....	.....	.....	.....	.....
Charpy	54	53	40	26	22	16	18	16	13
Impact shear	40	39	38	40	39	38	39	38	36
Annealed at 940 deg. C.									
Izod	38(?)	42	40(?)	.....	.....	.....	.....	.....	.....
Charpy	8.5	11	10	12	11	10	15	14	12
Impact shear	38	38	37	42	40	38	40	38	36
Quenched from 940 deg. C.									
Izod	112(?)	112(?)	90(?)	.....	.....	.....	.....	.....	.....
Charpy	62	54	43	40(?)	27(?)	17(?)	40(?)	27(?)	17(?)
Impact shear	50	47	41	50	46	41	47	45	42

will have to talk less about the curves they can draw by plotting impact results against any of the other chemical or physcial properties, and really tell us what happens when they hit a piece of nicked or unnicked metal an overpowering blow.

MR. J. J. SHUMAN (Pittsburgh): On this last slide (showing Mr. Thum's tabulation of rivet steels with varying sulphurs) I call attention to the figures for the Charpy test. I believe the Charpy impact method is a measure of the energy absorbed in cutting through the piece. If so these figures show clearly a comparison of a free-cutting metal with a metal that is not free-cutting.

You all know without my telling you that sulphur is purposely added in steel in order to impart a free-cutting nature. Accordingly any one in studying the tests that have been published by the committee on phosphorus-sulphur investigation, should bear in mind in comparing the Charpy results that they have developed the measure of free-cutting in the metal.

Observe the difference therefore that is caused by the addition of sulphur up to 0.06 or 0.08 per cent and note that it demonstrates clearly the value of screw stock, from the free-cutting or machining standpoint.

MR. LESSELLS: I think that if Mr. Lynch is here he will bear me out in what I am about to say. I very imperfectly tried to put before you on the second last slide, something from O. Lasche's publication showing that the speed of impact has got something to do with the results. I will say that it may be logical to compare the results of the Charpy and Izod but it is absolutely illogical to compare impact shear and any of these tests especially on low carbon material.

It has been demonstrated by Hadfield, and I think it is going to be

brought out by Mr. Lynch, that speed of fracture for impact is very important. Therefore if we are talking about any particular value that we get from an impact test, let us restrict ourselves to one particular machine.

With regard to the other question of notch brittleness, while I may say that notch brittle material may not be barred, if I could have two materials with the same elastic limit, I would prefer the material in constructional work which gives the high impact value—whether Izod or Charpy.

CHAIRMAN JOHNSON: Are there further questions on this paper?

MR. C. E. MARGERUM (Charleston, W. Va.): I would like to ask to what extent Mr. Lessells' tests indicate the effect of impact; that is, to what extent and in what direction the results are influenced by the fact that the load is imposed on the bar by means of the momentum of a ram, rather than by a mechanism which acts more slowly. I would like to know whether Mr. Lessells has found that the amount of energy required to break the bars was smaller when they were broken by impact than when the load was applied more gradually, or whether the reverse was true, or whether the results given represent the properties of notched bars irrespective of the method of applying the power.

In all the published results which have come to my attention in which the amounts of energy required to break notched bars by impact are compared with the amounts required to accomplish the same results by slow action, it has been found that with the single exception of bars of very coarse grained extra soft steel, more energy is required to break a notched bar by impact than by slow action. Do the tests under discussion confirm this observation or have exceptions appeared?

If more energy is required when the piece is broken by impact than if it is broken by slow action is not this contrary to the popular conception of the purpose of the impact test? I believe that the general impression is that impact tests measure brittleness under impact, that is, a deficiency of strength under impact as compared to strength under dead loads; but if in all cases but one the resistance to rupture by impact is greater than the resistance to standing loads, is it not likely to be misleading to refer to tests of this kind as impact tests?

MR. LESSELLS: I admit the error. It should be notched bar test really instead of impact.

Supposing you arrange bars small enough to get measures of the energy to bend them, then I am quite sure that would not be indicative or have any relation to the value you would have by actually notching the pieces. You can look upon a notch as a factor of safety. But as I have tried to indicate here, that impact and reduction of area has, or appears to have, a certain relation, then I think we could accept that a material which gives a higher Izod value is going to stand shock in service better than a material which gives a low Izod value. I don't know whether that covers the question or not.

MR. MARGERUM: I would like to inquire as to the appearance of the fractures. In a large number of tests made by Messrs. Charpy and Cornu-Thenard, in which many types of steel were tested, the appearance of the fractures, and the deformations of the bars were the same whether the pieces had been broken by impact or by slow action, except in the case of the very coarse grained extra soft steel, which was unique both in that less energy was required to break it, and in that the bars broke with a crystalline fracture and slight deformation of the metal bordering on the notch, when

broken by impact, while similar bars, broken by slow action took more energy, showed a fibrous fracture, and were much bent and deformed before they broke. It would be interesting to know whether Mr. Lessells' bars behaved in a similar manner. If this is true in all cases, impact brittle material may be detected with certainty by a simple hammer test and the so-called impact test is superfluous except as a convenient method of measuring notched bar properties.

MR. LESSELLS: I didn't know whether I made that point clear or not. I showed no photograph of a notch-brittle material.

MR. MARGERUM: Did you find that the properties of any of these samples were different when broken by impact from what they were when broken by slow action?

MR. LESSELLS: Oh yes, the rapidity of fracture has a lot to do with it, but as long as you keep the speed the same, as long as you keep that variable the same, your ground of comparison is sound.

Supposing, for the sake of argument, we are fracturing at the rate of twenty feet a second; as long as we keep twenty feet a second constant, it is quite a sound basis to compare. But the point that I indicated before was, unless that velocity is a given amount, it doesn't show up all these characteristics. So the thing I am trying to guard against is, if we are going to develop impact testing, let us have speed enough so that we will have all these variables cut out.

MR. C. B. DICKSEE (Pittsburgh): The British Air Board during the war issued several pamphlets on this subject inasmuch as they were confronted with considerable difficulty in reproducing tests when specimens were made rapidly and in quantities. The variations in the notch, particularly the radius at the bottom of the notch, had a great bearing on the results obtained. I also notice from Mr. Lessells' photographs that the depth of the notch was not uniform. In some cases I would say that the depth was 30 per cent greater than in others.

MR. LESSELLS: The depth of the notches appeared on the photographs that way, but at the works we can reproduce these depths of notches very accurately. You can't judge by the photographs. You see them at different angles and that masks the depth of the notches.

I think, however, that that is quite an important point. If we are going to introduce a dynamic test of this nature we must insure that we get and reproduce accurate notches. I think it can be done commercially with this proviso, that a proper cutter is used. It can be done— we do it.

MR. DICKSEE: Are not the different results obtained due to different types of notches.

MR. LESSELLS: That is why I say it is not fair to compare Charpy and Izod. If we are going to talk Charpy, let's talk Charpy, and if we are going to talk Izod, all right; but don't let's compare these values with shear values.

MR. KNERR (Philadelphia): Can you give us any information as to the behavior of low impact materials in service? That is, what does low impact really signify in practice?

MR. LESSELLS: There again I can't say very much on that. You see this form of testing was brought on by the war conditions more or less. It has been developed under war conditions and naturally under such we had not all the facilities for examining what happened to materials, but I would imagine that since an impact value is a measure of the grain

formation in materials, the one with the high Izod value is going to stand up longer in service than the one with the lower Izod value, all other things being equal.

MR. T. D. LYNCH (Pittsburgh): There is to be a symposiuum on impact testing of materials at the convention of the American Society for Testing Materials which meets at Atlantic City June 27th to 30th inclusive. The subject will be discussed under five headings, namely:

1. Resume of impact testing of materials and bibliography.
2. Machines and test specimens used in impact testing.
3. Standardization of machines and specimens for notched bar impact tests of metals.
4. Measurement of impact.
5. The significance of the impact test and its relation to other tests of materials.

This last sub-division will be discussed by Dr. F. C. Langenberg, Watertown Arsenal, who has given as much or more study to this subject as any one else. One entire session of the convention will be devoted to the subject of impact testing.

Referring to the slides that Mr. Thum put on the screen and which was commented on by several of the men present, I would like to point out one thing in connection with the chemistry of the steel referred to, covering the report of the joint committee on phosphorus and sulphur in steel. All of the steel so far tested is very low in phosphorus, under 0.02 per cent, and the discussion brought out here, should not be permitted to confuse our minds with a high phosphorus steel that may be high or low in sulphur. We have found from some personal tests which we have made, that steel, known as open-hearth automatic screw stock, having low phosphorus but high sulphur, gives us very good results on tests such as have been made by the phosphorus and sulphur committee, but where we have high sulphur together with high phosphorus we would expect a brittle material. There are so many complications in steel that it would be unfortunate if the report of the committee on phosphorus and sulphur in steel were construed to mean that high sulphur did not affect steel of any quality.

MR. ALLEN (Springfield): I am sorry Mr. Lessells did not make more mention in his paper of the Stanton test as it is one in which we place considerable confidence. Assuming that the design is reasonably correct it is seldom that a piece snaps off short in service under impact test conditions, but, unless extreme watchfulness is exercised, failures will occasionally occur by fatigue either through faulty material or heat treatment. The Stanton, with its small impact blow repeated many times, alternately stressing the fibres in tension and compression, approximates more nearly actual operating conditions and hence the results obtained are a truer criterion of the ability of the material to resist fatigue and thereby stand up in service.

Where life tests can be made on finished parts, road springs for instance, we have found that the Stanton parallels the actual life results more closely than any other type of test we have tried up to the present time.

The machine is rather unique in that results can be duplicated with considerable accuracy which is not the case with most impact tests and the conditions of test can be easily varied as the height of the hammer drop can be altered to produce any stress desired. The Stanton machine, although of English origin, is now being duplicated in a somewhat modified form

by one or two of the American testing machine manufacturers; the test is well worthy of more consideration than is being given to it at present.

MR. LESSELLS: It might interest Mr. Allen to know that the Westinghouse Company intend to develop this form of test—this Stanton test. We also believe that it is indicative of the capabilities of the material to stand fatigue, and as I indicated very briefly, the fractures of a Stanton show all the characteristics of a fatigue fracture.

MR. W. J. MERTEN (Pittsburgh): In looking over the diagrammatic chart of Mr. Lessells, it seems to me it is very evident, since the Izod test does follow the reduction of the area curve, very closely, we should expect from an Izod test of high value a great deal of ductility of material, and it seems also to indicate high resilience.

I would like to point out some inconsistencies on the part of the British Institute tests. With a wide variation in ingredients, such as manganese or silicon, we should expect a difference in Izod values because of the increased values of silicon and manganese. I don't think any of us here will admit that 50 per cent higher silicon and 50 per cent higher manganese would not have a decided effect upon the Izod value of the steel in the tests described.

MR. LESSELLS: One slide is No. 14 and the other No. 15. Show them again, please.

Now, here, if this is true as Mr. Merten suggests, that the tempering temperature has no bearing on the change in physical properties which obtains, then the next thing I am going to say is that the silicon and manganese limits should appear in all material specifications.

MR. MERTEN: What I wanted to point out principally was I don't believe the quenching temperature of 30 degrees Cent. has an influence in the change of properties there, because in both cases you will be in the solid solution range at 870 degrees Cent. as well as at 900 degrees Cent. But the silicon as well as the manganese, being deoxidizing agents and alloying elements, produce an entirely different texture in the steel. And I think the Izod test is of value in showing up this particular condition.

CHAIRMAN JOHNSON: Is there further discussion?

MR. THUM (New York): There is considerable emphasis made on the point that the Izod parallels the ductility as determined by tension tests. I have no doubt that is true for the steel in question, but I would like to point out that in the sulphur investigation to which I referred, such is not the case. The rivet bars, as received showed that sulphur has very little effect on ductility, as determined in the ordinary tensile machine.

I really believe that the question about notching raised a minute ago is a good one. Engineers and constructors do not put notches into their machines if they can help it. Therefore a steel maker who is asked to furnish material for a certain impact value, could rest his case on the impact shear, and in the case of rivet bars for instance, the impact shear would give excellent results with high sulphur.

Consequently, it seems to me it is up to either this Society or some other society who are interested in the subject, to determine just what notched impact means, and what it can be used for.

Discussion of Mr. Cox's Paper

MR. E. E. THUM (New York): I would like to ask a question. Fig. 11 in the paper shows a microstructure of case hardened steel. I would judge that the caption there is incorrect inasmuch as that structure is characteristic of carbonized material before hardening. I doubt if you would get high hardness out of such a structure. The same is true of Fig. 12. Were those taken before hardening?

MR. COX: No, they were taken after hardening. That was the hardened structure.

CHAIRMAN BOYLSTON: The two illustrations in Fig. 11 have apparently been reversed somehow. The coarser grain corresponds to the single treatment and the finer grain to the double, does it not?

MR. COX: The finer grain is the double heat treatment.

MR. J. M. LESSELLS (Pittsburgh): First I want to say that Mr. Cox ought to be complimented on a paper of this nature, because it is something new. It is a new way to show an old subject.

My first question is: Was the machine checked up by running a large number of tests on material of a similar Brinell? In the variables you have shown the same material with different Brinell hardnesses.

MR. COX: That is what we did when we picked out the 555 and 444 and 302 range for each of the hardened steels.

MR. LESSELLS: The same material with different Brinell hardnesses and the same Brinell hardness for different materials?

MR. COX: That is practically what I have given in the paper. For instance the plain carbon steel—0.50 per cent carbon, that was shown in the 555 range, the 444 range and the 302 range.

Now as far as different steels go, in the chrome nickel, the parallel steel was also shown in those three ranges, which would take care of both questions. And as far as other tests are concerned, we have been making tests on the machine over a period of at least five years, so that when these tests were taken for this paper, comparison was made between the results we got on these test pieces and the test pieces that had gone before. They checked.

MR. LESSELLS: The question is, how far a machine of this nature is able to duplicate results? You have four steels here which show a very peculiar relationship. For instance, in the summary, you say the greater the density and hardness, the greater the abrasive resistance. I think that is one of the conclusions.

Now the Brinell tests do not show abrasive qualities, but a denser material; I mean, a material with a Brinell of 444 would be a more dense material than a similar material with a Brinell of 200, wouldn't it?

MR. COX: That is a question that has not been definitely proven.

MR. LESSELLS: If that is so, if the material increases in hardness with increase in density, then there ought to be some relation. The results evidently conflict there.

I would like to ask what provision was made to insure that the surfaces were all alike?

MR. COX: After each run you would naturally have a sort of powdery surface, and the main rolls were cleaned off and the test rollers were cleaned off in ether.

MR. LESSELLS: Run at the same speed?

MR. COX: Same speed, and weighed on the same balance.

MR. LESSELLS: This paper really raises a question of vital importance to engineers in general. For instance, it has always been my experience that running a case hardened steel pin in a case hardened bush, is bad practice, but to run a case hardened steel pin in a tool steel bush gives decidedly better results.

MR. COX: We have found that various combinations work out better than others.

There is a certain combination that worked out very nicely and they received great wear results from it; that is, for the driver to be Hadfield manganese steel and the driven cast iron, both of them comparatively soft materials, and they got very good wear results. Therefore, that brings out another point that should bring forth investigation along the line of making a comparison between various types of steel and operating in the same identical service in different combinations, in order to bring out suitable steels for each service.

Now if you will bear with me, during the war period we were hard pressed to get out a large order of street car railway pinions, and the only steel that was available was a chrome nickel steel. Approximately 500 pinions were made up of this chrome nickel steel and they averaged in hardness from 444 to 500 Brinell. They went into service and stood up approximately between 10,000 and 20,000 miles, whereas in the same service the specially brine heat treated pinion gave a service of between 50,000 and 60,000 miles, which bears out the idea of investigating different combinations and investigating different services.

There has been very little published along the line of abrasive resistance, because when I started to write up this paper I visited the Central Library at Carnegie Institute, and about the only item I could find on abrasive qualities was in grinding wheels. That naturally didn't apply to this paper. So that I hope this will be a starting point, although we really can not draw real conclusions from what we have done. But it is to be hoped that a more general investigation will be started along the abrasive resistance of metals.

MR. W. B. CROWE (Pittsburgh): There is one term that is very confusing with reference to hardness, and that is the application of the word "density." Just what is meant by the term, as applied to hardness? Does it have any reference or relationship to specific gravity, or just what is meant by it. It has always been my conception that a hardened steel is less dense than a softened steel of the same kind. So I have often wondered what was meant by the term "denser structure" with increased hardness.

MR. COX: We always understood the term "density" was used in more of a specific gravity sense, and hardened steels we have always found to be denser than the untreated.

MR. CROWE: I have heard of investigations that have been made on steel, in the martensitic and pearlitic phases, where a lower specific gravity was found on the martensitic steel, approximating one per cent, which is contradictory to the ordinary term as applied.

MR. COX: That is probably due to martensite formed in tension. It might be, if you have a piece that is martensitic, that you would have lower specific gravity than with a piece that combines the two.

MR. GROSSMANN (Charleroi, Pa.): It seems to me that the term

"density" is more of a colloquialism which refers to the appearance of the fracture of a piece of hardened steel. There is no question at all that a piece of hardened steel, in a martensitic condition, is less dense with regard to specific gravity than a piece of annealed steel. You will have a much finer grain, a "closer" grain, and that is where the term "more dense" has come from, I believe. I believe in practically all cases, socalled dense steel with a fine grain is really less dense in the sense of the specific gravity.

MR. MORGAN (Pittsburgh): This test is a very interesting test, and if I might be pardoned, I would like to ask you a question. I like to compare. As I understand it, the two large rollers are cast manganese steel. From the sketch I would judge that perhaps the surface, the contact surface, of each individual one was something like four times that of your test roller?

MR. COX: Surface? The rollers were three inches in diameter and the test roller was one inch. That would be 3 to 1.

MR. MORGAN: And they would divide the slip perhaps equally so that you would have about 6 to 1. I wondered how many tests you could run on those manganese steel rollers, which would give some conception of the relation in resistance to abrasion of the test pieces in comparison with manganese steel?

MR. COX: In comparison with manganese? Well, the only way there would be is to make up the manganese steel, in the same form as the test roller itself, unless you ran, say, the same test roller for quite a period of time and then dismantled the machine and weighed up the manganese large rollers.

MR. MORGAN: The question might be answered, by how long these manganese steel rollers stand up.

MR. COX: Well, they were newly ground when we started that series of tests and they wore down approximately a thirty-second of an inch when we had finished.

MR. MORGAN: The test rollers are prepared by grinding?

MR. COX: By grinding. First they are heat treated, leaving about ten thousandths on the diameter, for grinding, so that in case there was a slight decarbonization in heat treatment that would be eliminated.

Discussion of Mr. Succop's Paper

MR. HOFFMAN (Pittsburgh): What bearing would rapid or slow cooling in hardening have on the quality of the block, and how would it affect the curves such as you have shown, say with one cooled in oil, one cooled in water at 100 degrees Fahr. and one cooled with a spray?

MR. SUCCOP: The water cooled block is going to contract faster than the oil cooled block.

MR. HOFFMAN: Would you consider quenching in oil superior to quenching in warm water?

MR. SUCCOP: I think that the warm water approaches the oil and it depends upon the desired results. If you want hardness you want a quick quenching medium. The oil will give greater ductility after quenching than the water.

MR. HOFFMAN: I had reference to a heat treated block where you have a Brinell hardness of 350 and perhaps would be compelled to use a draw back. If you have a block 18 inches square and put it in oil, would you

cool that block evenly all the way through, so that you would have a heat treated block, with a Brinell hardness of 350 at the center?

MR. SUCCOP: We have found in large die blocks, which were quenched and cut in half, the scleroscopic hardness from the surface to the center, was found to vary only 5 points.

MR. HOFFMAN: Cooling in oil?

MR. SUCCOP: Cooling in water.

MR. HOFFMAN: Could you have gotten the same results if you had cooled it in oil?

MR. SUCCOP: I don't know, we never tried it.

MR. JOHN J. CROWE (Philadelphia): Fig. 3 curve III which indicates the temperature at the center of the oil cooled specimen shows a sharp break at 1200 degrees Fahr. In Fig. 4 curve II a similar break occurs at 450 degrees Fahr. The break is shifted from the center position to a position 4.5 inches from the outside. How do you explain that?

MR. SUCCOP: You mean that the center cooled off more rapidly in the water cooled than in the oil cooled?

MR. J. J. CROWE: If you look at curve III on Fig. 3 the curve for the thermocouple placed at the center of the cube at 1200 degrees Fahr. after 38 minutes there is a point of inflection in the curve, it shows a sharp break. This same characteristic is shown in curve II Fig. 4 at 450 degrees Fahr. after 36 minutes. The point of inflection has been depressed 750 degrees Fahr. and has been shifted from the center to the position noted as No. II, 4.5 inches from the outside, half way between the center and the outside.

MR. SUCCOP: I cannot answer that.

MR. J. J. CROWE: That is something that may be worth studying. In doing some work several years ago on the temperature distribution in the head of a 90-pound rail, I placed one thermocouple just under the surface and another at the center and after heating to well over the critical range allowed the rail to cool in air. The outside cooled much more rapidly than did the center until the critical range was reached when there was an actual reversal on a differential couple indicating that the outside was slightly hotter than the center.

MR. HOFFMAN: Were your blocks, or eighteen inch cubes chrome nickel or plain carbon?

MR. SUCCOP: Plain carbon.

MR. HOFFMAN: I notice for the 18 inch block you use a 25 inch ingot. Would you consider that the proper proportion of reduction for all blocks?

MR. SUCCOP: That is not as much as is regularly given. But that is the way E. F. Law developed these curves. That is not of course as much as is regularly given, usually there is a greater reduction. I would say, rather than a 25 inch ingot, a 30 or 32 inch ingot should have been used for the proper reduction.

Discussion of Mr. Grossmann's Paper

CHAIRMAN BOYLSTON: We have a short written discussion from Mr. S. C. Spalding of the Halcomb Steel Company.

Chairman Boylston read the written discussion of Mr. Spalding which is as follows:

I was greatly interested in the data published by Mr. Grossmann on the change in dimensions of high speed steel in heat treatment. This is a subject worthy of considerable attention, but as Mr. Grossmann states, printed data on the subject is hard to find. It was surprising to me that the author found the steel to expand in hardening. It has been our general experience that a high speed steel will shrink in hardening. To confirm this statement, I give here some measurements made on a steel of the type of Mr. Grossmann's No. 18.

Two bars of high speed 7/8 inch in diameter were selected and two cylinders made from each bar, 13/16 inch in diameter by 3 inches long. The cylinders were carefully measured, then hardened and measured, then drawn and measured. The results follow:

	Length in Inches	Difference in Length in Inches	Diameter in Inches	Difference in Diameter in Inches
	Piece No. 1			
Before	2.9719	.....	.8122	.....
2200 degrees Fahr. in oil	2.9692	—.0027	.8112	—.0010
Drawn 1050 degrees Fahr.	2.9683	—.0036	.8113	—.0009
	Piece No. 2			
Before	2.9967	.....	.8121	.....
2250 degrees Fahr. in oil	2.9937	—.0030	.8111	—.0010
Drawn 1050 degrees Fahr.	2.9927	—.0040	.8111	—.0010
	Piece No. 3			
Before	2.9895	.....	.8120	.....
2200 degrees Fahr. in oil	2.9874	—.0021	.8114	—.0006
Drawn 1050 degrees Fahr.	2.9862	—.0033	.8115	—.0005
	Piece No. 4			
Before	2.9892	.....	.8122	.....
2250 degrees Fahr. in oil	2.9864	—.0028	.8111	—.0011
Drawn 1050 degrees Fahr.	2.9854	—.0038	.8111	—.0011

To see what effect the shape of the cross section would have, two pieces, one each of bar No. 1 and No. 2 were made up in tap sections 3 1/4 inches long, measured, hardened at 2250 degrees Fahr. and measured, then drawn at 1050 degrees Fahr. and measured. The results follow:

Bar No. 1

2250 degrees Fahr. in Oil—Drawn 1050 degrees Fahr.

	Length in Inches	Difference in Length in Inches	Diameter in Inches	Difference in Diameter in Inches
Before	3.2155	.....	.8101	.....
After hardening	3.2118	—.0037	.8088	—.0013
After drawing	3.2107	—.0048	.8083	—.0018

Bar No. 2

2250 degrees Fahr. in Oil—Drawn 1050 degrees Fahr.

	Length in Inches	Difference in Length in Inches	Diameter in Inches	Difference in Diameter in Inches
Before	3.2105	.....	.8094	.....
After hardening	3.2054	—.0051	.8083	—.0011
After drawing	3.2037	—.0068	.8079	—.0015

This shows No. 1 to have shrunk .0015 inch per inch of length and No. 2 to have shrunk .0021 inch per inch of length. This shows that the tap section which contains less metal apparently shrinks more than the solid cylinders. This in turn would indicate that temperature and length of time in the furnace would have an important bearing on the shrinkage.

It would seem that there must be something radically different, either in the condition of the steel or in the treating that would cause Mr. Grossmann's test pieces to expand and ours to shrink. Ours were preheated to 1750 degrees Fahr. in a wire resistance electric furnace, then transferred to a carbon plate electric furnace at the required quenching temperature, left until they were judged right by a high speed hardener, then quenched in oil. It would be interesting to hear expressions from members present who have had experience with high speed as to whether they have usually found it to expand or shrink.

MR. GROSSMANN: I am sorry to discuss this paper of Mr. Spalding's in his absence because I would like to ask him what I think would be the vital point in it, and that is regarding the protection of the ends. If those pieces hardened in an open furnace as he implies, were not protected on the ends, a certain scale would form which would either flake off or perhaps be removed or smoothed in order to make the measurement easier. I know of certain tests that were made on the same steel that I used in these tests, were treated in that way, and they apparently showed a shrinkage, but so far I have made probably fifty tests on steels of four different types—these three and a cobalt steel, high speed, and they all expanded without any exception. They were preheated to 1600 degrees Fahr. and then transferred to a high speed gas furnace at the temperatures at which the tests were run and left there in the neighborhood of 5 minutes and then quenched in oil.

MR. MERTEN (Pittsburgh): Mr. Grossmann spoke of formation of carbides on cooling and changes due to this formation. Doesn't he rather mean the precipitation of carbides instead of formation? I don't think carbides are destroyed or broken up by heating through any temperature except probably when heated to a liquid state. Doesn't he mean precipitation instead of formation?

MR. GROSSMANN: There seems to be considerable controversy on that particular point just now. There are two rather opposing views. One of them is that carbides and tungstides, or whatever they are, dissolve in atomic dispersion, and the other view is that they dissolve as a whole. In one case the formation, or precipitation of the carbides and tungstides would mean association of the atoms to form the molecules, and then an association of those molecules to form the larger particles.

The other view would mean merely that the molecules are preserved as a whole, while being dissolved in the matrix and that they merely associate to form the larger particles which are later visible under the microscope with higher drawing temperatures.

MR. MERTEN: I don't believe that volume changes indicate a molecular disintegration and atomic dispersion. I don't know whether these high sounding atomic dispersion theories have any bearing whatever on your problem.

MR. GROSSMANN: I think the question of whether they are in atomic dispersion or molecular dispersion has very little to do with it but the association of either the atoms or the molecules has a great deal to do with the accompanying contraction of volume.

MR. MERTEN: I have always been able to explain to myself and others the volumetric changes in the precipitation of carbides, and I think the twinning theory explains the volumetric increase in your structure. It makes it rather hard to see why a volume should increase by a formation of a chemical union between iron and carbon, if such a thing is possible, at this temperature. From that standpoint I think the precipitation of carbides is more plausible to the average man than another explanation.

MR. HOFFMAN: In summing up your paper, did I understand you to say that the proper drawing temperature at which you would have the steel retain its original dimensions to be 900 degrees Fahr.

MR. GROSSMANN: As far as these tests have gone, yes. The steel can be drawn of course at 900 degrees Fahr. and still retain almost all of its original high speed cutting properties, and yet at 900 degrees Fahr. it will be nearest to its original dimensions.

MR. GREEN (Philadelphia): I would like to ask Mr. Grossmann how deep were the holes and tappings that those bolts were sunk into to hold the pieces on the ends, and whether or not the holes being in the piece caused any differences in the measurements. That is, if you look at your Fig. 1, how deep were the holes drilled to put the bolts in?

MR. GROSSMANN: A half inch deep.

MR. GREEN: You took the measurement in the center. You don't think it could have affected the conditions one bit, having those holes there?

MR. GROSSMANN: I hardly think it could have affected it.

MR. THUM (New York): The discrepancy of the results in Mr. Grossmann's work and that of the Halcomb steel company seems to be great.

I happened to look up some work of Mr. Scott of the Bureau of Standards and he gives expansion curves that are very similar indeed to Mr. Grossmann's curves. There is a striking parallelism in that the quenched specimens are always larger in volume, than the annealed bar. On successively higher drawing of quenched bars he got a slight contraction followed by an expansion when the secondary hardness appeared. On even higher tempers (anneals) there is a sharp contraction. In other words, Mr. Scott's work of the Bureau of Standards seems to verify Mr. Grossmann's work as near as could be expected.

MR. HOFFMAN: A lot of the results depend on the method in which the samples were heated. The one which Mr. Grossmann used and the one used by Mr. Spalding may have been different, which would account for the variation in results.

MR. GROSSMANN: I can't say that I can see any reason why such differences in heating would have that effect.

MR. HOFFMAN: Your specimens were not subjected to the flame.

MR. GROSSMANN: They were heated in an open gas furnace.

MR. HOFFMAN: Your specimens were not heated in an enclosed capsule?

MR. GROSSMANN: No.

MR. HOFFMAN: The other was an electric furnace. Yours was a gas fire. It may have some bearing on the results.

MR. GROSSMANN: It may have, but I question whether, at that temperature the gas absorption would be great enough because the higher the temperature of a piece of steel, the less it is susceptible to gas absorption.

MR. COX (Pittsburgh): There is one point there. Your preheating was done at a temperature of 1600 degrees Fahr., and the Halcomb Steel

Company preheated at 1750 degrees Fahr. There is a difference of 150 degrees Fahr. and the rate of preheating would be greater in the 1750 degrees Fahr. than in the 1600 degrees Fahr. It might be possible that there is a difference in the types of the preheating and heating up for final quenching.

MR. GROSSMANN: Yes, but we have made a few tests in which the preheating temperature was as high as 1800 degrees Fahr. and we found always the same expansion.

MR. MORGAN (Pittsburgh): Isn't there a condition incident to the treating of any steel, that, if you please, may waive consideration of these supertechnical points?

When we cool a piece of steel in any medium, all papers that we have heard in the last couple of days have indicated that we do not cool the steel at a uniform rate from surface in. When we cool steel we find that we set up tremendous shrinkage stresses. You cannot have stress without a strain. The minute you set up shrinkage stresses you must have a change in dimensions that go with them, and when you draw or anneal or pass through any other operation in drawing, or whatever it may be, the shrinkage stresses and corresponding strains adjust themselves to each other.

So that the point I want to make is that the conditions of heating and the conditions of cooling and drawing, the intimate conditions, the detailed conditions, would be largely vital in affecting the final mass of the material passing through such treatment.

I would like to inquire if Mr. Grossmann thinks that would have any bearing.

MR. GROSSMANN: I think it might have a considerable bearing on large masses on account of the stresses that are set up in the steel due to the temperature gradient between the outside and the center. This has to do more with the normal thermal expansion because as a piece of steel is cooled, aside from these volumetric changes that we have discussed here, there is a normal contraction in cooling, and of course the outside tends to cool more rapidly than the center. The center, since it doesn't cool as rapidly as the outside, has a larger volume so that it induces in the outside certain stresses which might cause an expansion, a purely mechanical expansion, accompanying the tendency toward contraction. I don't know whether I make myself perfectly clear on that but I think you can readily see that if a large block of steel as in Fig. X is at a temperature of say 1800 degrees Fahr., and is suddently plunged in water so that it is caused to cool rapidly on the outside, then dimension A, we will say, where it is all exposed to the cooling medium, will tend to contract from the dimension A, down to one like dimension B, exaggerating it a great deal. The center, being much hotter, will naturally have a larger volume. It will have almost its original length equal to A and since this outside piece A tends to assume this length B and the center piece holds it to about this other length A, naturally there will be an intense strain on this outside, tending to hold it to its original length, and that might have a great deal to do with it in a large block. However, the center being hotter is more plastic and will yield more to the contracting force from the outside.

Whether it would have much to do with it on such a small block as this test piece, I rather question.

MR. H. J. STAGG (Syracuse): I think a point has been missed by both

Mr. Grossmann and Mr. Spalding. Attention has been paid to the differences in length and in length only. So far as I have seen in a cursory examination, there has been no attention paid to the differences in diameter by either Mr. Grossmann or Mr. Spalding, and I think perhaps some investigation along those two lines may reconcile the results of the two investigations.

A number of years ago I obtained a mass of data that was irrevelant until that point occurred but gradually after taking into consideration the changes in shape of both dimensions, results came to light which were worth while.

MR. GROSSMANN: I might say in reply to that, first that the series of measurements made by Mr. Scott in the paper referred to by Mr. Thum showed that the volume changes which were measurements of actual specific gravity, conformed rather closely to these results shown here.

The other answer that I might make to that has to do with a surface action. I don't know if Mr. Stagg has reference to the same point, but it is rather well known that if a cylinder of about the proportions shown here is heated repeatedly and then cooled quickly a certain surface action comes into play. ..... Now here, if a cylinder like this shown in Fig. Y is heated to a moderately high temperature, disregarding the critical changes, it is found after a number of quenchings, say 100 or 200, that the cylinder instead of having its regular shape, will be bowed out, like that, shown in Fig. Z, throughout the section which would indicate a contraction axially, in dimension M.

On the other hand, it is found that the cylinder, instead of being straight across as at S in Fig. Y, is actually bowed out here also, as in R in Fig. Z, and the same at the bottom. It seems that the tendency is for a piece of steel like that to assume a perfectly spherical shape; but that effect is not noticed to any great extent, at least, it was not noticed in some tests we made, until perhaps 50 to 75 quenchings had been made, and it seems to me very doubtful that such an effect would have much bearing on these measurements

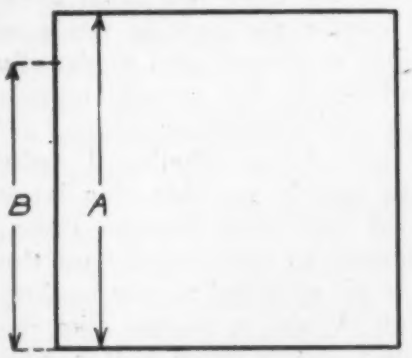

FIG. X

Fig. X. Diagrammatic sketch of the change in dimension of a steel block when heated to 1800 degrees Fahr. and quenched in water.

Fig. Y. Diagrammatic sketch of a steel cylinder before it has been heated and quenched several hundred times.

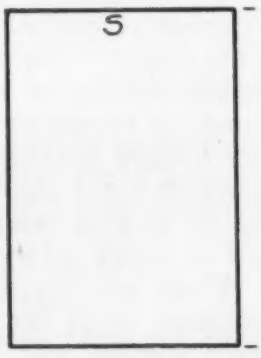

FIG. Y

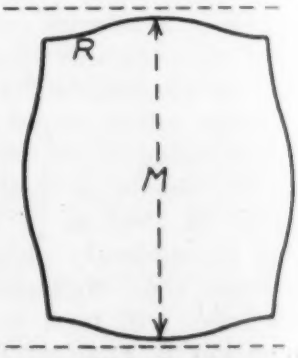

FIG. Z

Fig. Z. Diagrammatic sketch of the steel cylinder shown in Fig. Y after it has been heated through the critical range and quenched several hundred times. Note that the cylinder tends to assume a spherical shape.

because, in the first place these had only one quench, and in the second place, if there was a tendency toward contraction, which I grant there is, it would be slightly compensated for by the tendency to bow out at the upper and lower ends.

MR. KNERR (Philadelphia): In that connection I would like to ask whether you made measurements to determine whether the ends of the

cylinder remained parallel after quenching, or whether there was a bulging at the axis as compared to the length at the outside?

MR. GROSSMANN: Unfortunately we couldn't make those measurements because with this cylinder the ends were oxidized very badly 1/3 of the way in, and it was only in the center that the steel remained perfectly clean. So that we couldn't tell whether there was surface action there or not. I rather suspect that with the short heating it would be found that the outer part was expanded more than the central part. But I have no data on that.

MR. W. B. CROWE (Pittsburgh): I have had experiences in connection with the hardening of armor plate, that connects up very well with this subject. Armor plates which are face carbonized, are treated to produce the desired physical properties for the back, usually very uniform throughout the entire section. It is then subject to a face hardening operation, face heating, and face and back spraying, which will carry the hardening down to desired depth approximately 30 to 40 per cent.

It has always been our experience that when a plate has been so heated and quenched as to have no appreciable effect on the physical properties at the back, and the face has been rendered nearly glass hard, the upper hardened face will rise in the center very considerably. A plate 20 feet long will often rise 6 to 10 inches. To satisfy myself, in one case I placed two center punch marks 10 feet apart on longitudinal axes of surface, before heating for hardening. After hardening these punch marks were 1/16 inch farther apart and the calculated curvature this would produce checked very closely with the actual curvature induced.

I also observed that where in special cases a foot or so of the edges of the plate were protected to keep soft for subsequent sawing off, that when the cut had been carried nearly the entire length of the plate, the narrow, unhardened strip became nearly straight as compared with the hardened plate, the face end often leaving a foot or more above its original position. With these counteracting forces removed, the hardened body of the plate becoming slightly more curved. Inasmuch as the physical properties of the unhardened portion of the plate had been practically undisturbed, it would appear that the hardened face had expanded.

CHAIRMAN BOYLSTON: I would like to ask Mr. Grossmann what he means by two different types of martensite?

MR. GROSSMANN: There is pretty distinct evidence in high speed steels that there are two forms of martensite present; one of them the kind which is, let us say, "destroyed" by heating at the low temperatures up to 900 degrees Fahr., and the other which is only developed from the austenite in high speed steel by heating at 1100 degrees Fahr. I cannot say what the constitution of those two martensites is, but it is certain that martensite formed from the austenite at 1100 degrees Fahr. is much more stable than the martensite which is in the high speed steel as originally hardened. We can show this, for one thing, by heating high speed steel to 900 degrees Fahr. and it will lose some of its hardness. If it is then heated at 1100 degrees Fahr. it will acquire what is called secondary hardness due to martensite, and if this martensite, this new martensitic steel, is then reheated at 900 degrees Fahr., it retains the hardness which it had after heating the first time at 1100 degrees Fahr.; if it were the same kind of martensite as the original martensite, it would be destroyed at 900 degrees Fahr. the same as the original martensite. But this is not the case.

RELATION OF THE UNIVERSITY TO INDUSTRY

By Dr. J. G. Bowman

I am asked to talk about the relation of the University to industry, that is, the production of the University in its relation to industrial success, especially in the Pittsburgh district. I like to use your word here "production."

The budget of the University of Pittsburgh is about $1,500,000 a year. Our "production" this year will be about 600 graduates, about one-half of whom will go into the industries. The cost of training these young men and women during the past four years is conservatively about three million dollars. In other words, the community and the state of Pennsylvania contribute about three million dollars a year for the happiness, the prosperity, and the permanence of the state by investing in these youngsters.

Now, what about the product? Is it what you want? Is it all that we should have made out of it? You can employ today almost an unlimited number of engineers, technically trained, for $1,500 a year. You can employ doctors, dentists, and lawyers for the same amount, but can you employ a man trained in any one of these professions who knows not only the technical side of his profession, but knows also how to enter into the life of his community and be a part of it. A man in almost any profession today who has a sound training and also the gift of being part of his community is a bargain at $10,000 a year.

Now, what about our product. Are we turning out the $1,500 or the $10,000 man? Are we permitting a boy to leave the School of Engineering or the School of Medicine with merely a technical training, or have we some process by which a lad acquires both the technical training and that additional something which sets him free to go with speed to the top.

What is this "additional something"? There is no single answer to the question. The best answer, however, which I know is that it is the ability to get another man's point of view with sympathy and kindliness and speed. It seems clear to all of us in the University that it is our business to insist that the boys who are going into a professional career lay in for themselves a foundation which will broaden forever their points of view. Hundreds and hundreds of boys come to the University each fall and say, "I want to be an engineer. I want to be a doctor. I want to be a lawyer. I want to plan and build something." They are impatient. They want to go "right into technical training". The medical student, for example, wants to study anatomy and pathology before he has laid the basic foundation of medicine in chemistry and biology.

The engineering student is impatient when he is asked to acquire at least an elementary knowledge of economics and history and when it is insisted that he should know how to use his own language in a simple, straightforward manner which goes to the mark. If we should allow these boys to choose entirely their curricula, unguided as they are at the start, we should be turning out seldom better than $1,500 man and you,

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A speech delivered at the banquet of the Pittsburgh Sectional Meeting, May 25. The speaker, Dr. J. G. Bowman, is Chancellor of the University of Pittsburgh.

well, you would be complaining that you do not want many of these men.

What happens is that we require engineers, mining students, medical students and students in training for business to go at least two years to the College before they start on their technical training. In these years emphasis is placed upon training in the use of their own language. There is insistence that they know the elementary principles of economics and of government. The meaning of a profession is brought home to them and the responsibility of a man who enters a profession to his fellows. In other words, we try to open the windows on all sides of the little room in which the man starts out as a freshman, and with this scenery before him he is able not only to choose more wisely the career into which he will throw his life, but also to see more clearly the relation of his life to those about him.

The reading of biography is a habit which we endeavor to create among students. If a boy, for example, reads the life of Lincoln and really sees the horizon as Lincoln saw it, he will never again be quite as limited as he was before he read the book; he will have increased permanently the radius of his own horizon; he will have gained the power to grasp anothers' point of view with more sympathy, more kindliness and more speed because he knows the life of Lincoln.

The habit of using those little five and ten minute periods through the day that are wasted by most of us, for the reading of things like the life of Lincoln is a great habit. Many a time it is the difference between success and failure. It is a very important part of what a man gets out of a college education. And then if the student's life is full every minute of determinatnon to go to some high mark of attainment and he realizes that each day's work is progress straight toward that mark—that is the stuff which makes the University.

If you are to perpetuate your industries you must bring in constantly training and experience which you cannot give in your industries. Neither the engineer, nor the chemist, nor the doctor, nor the lawyer can acquire his essential skill without academic training, and the time is now here for co-operation between universities, let me say the University of Pittsburgh, and the industries of Pittsburgh, for the production of men who have got the energy, the intelligence, and the character to hold Pittsburgh in first place among world industries.

BALL STEEL

By Hilton G. Freeland

THE subject of this paper is ball steel from the ball manufacturer's viewpoint. There are other phases to this subject, for example, that of the steel mills and of the bearing makers, but this paper deals with the ball manufacturers' problems arising from the quality of the ball steel received and its effects on the final product. The writer will show what is considered good ball steel by describing the types of defects which are most common and by explaining why they are so injurious to the quality of the ball makers' product. It will also be shown how certain operations tend to accentuate certain defects during production, also how their presence is discovered in the raw material as received.

At the plant with which the writer is connected the product consists chiefly of the most perfect type of balls which are to be used in standard, high grade, radial and thrust bearings that are required to meet the most exacting type of service. In addition to this balls produced for Brinell machines, valves, and for uses in which alloys such as stainless steel, Monel metal, brass, bronze, aluminum, etc., are to be preferred, but for the purpose of this paper we will confine ourselves to steel only.

At present, four different kinds of steel are in use which in order of their importance, based on output, are:

1. Regular ball steel for ball bearings
2. Steel for oil well valve balls
3. Steel for valve balls and bearing balls where resistance to corrosive action is of prime importance
4. Steel for Brinell balls

We will study only the first type, our regular ball steel for ball bearings.

This ball steel is electric furnace chrome carbon steel. The carbon range is between 0.95 per cent and 1.05 per cent, while the chromium content increases with the ball size. For ball sizes ranging between 1/8 inch and 5/8 inch inclusive, a 0.75 per cent to 1.05 per cent chromium is used; balls from 5/8 inch to 1 3/16 inch inclusive, have from 1.05 per cent to 1.35 per cent chromium content; above that 1.35 per cent to 1.65 per cent. The other elements are as follows:

	Per Cent
Manganese	0.30 to 0.45
Phosphorus under	0.025
Sulphur under	0.025
Silicon	0.20 to 0.35

It is extremely seldom that any dispute arises over the composition of the steel furnished. A laboratory comparison of different analyses has indicated that a variation in composition from that which is specified would not be advantageous. It has been stated that additional chromium is present in the compositions used for the larger sizes of balls. This is found necessary in order that the required hardness penetration may be procured so that the larger sizes of balls may support loads proportional to their size. Increasing the chromium content of the larger ball sizes simplifies the heat treatment by reducing the sensitivity of the metal to the effects of both heat and time.

A paper presented before the Detroit Chapter. The author, Hilton G. Freeland, is metallurgist, Hoover Steel Ball Co., Ann Arbor, Michigan.

The ball steel that we now use, owes its quality to the sincere co-operation of the steel mills with our laboratory and organization, and represents a tremendous expenditure of time and money; time in developing a mill practice which is capable of eliminating our main sources of trouble, and money required to defray the cost of these mill experiments and changes, also to cover losses incurred through rejected material. All mills which can successfully and consistently produce good ball steel have traveled the same path.

The chief types of steel defects which cause the greatest trouble in the production of steel balls are two in number, seams and decarbonization. The following are some of the reasons for this statement:

1. No metal is removed from the surface of the stock before forming; in addition we are limited through mechanical and production reasons from removing more than a certain amount of metal afterward.

2. The forming operations tend to accentuate certain defects in the material used.

3. The whole process of ball production after forming is fundamentally a grinding operation, and grinding is expensive.

4. The only way we can be absolutely positive that the finished product is free of the evil effects of seams and decarbonization is to procure raw material so nearly free from the defects mentioned that we know all traces of both have been removed before heat treatment of the balls. We will not dwell on methods of ball production except as necessary to show that the defects mentioned are serious, and the manner in which their evil effects become multiplied during production.

There are a number of ways of producing spheres both for the forming of ball blanks as well as for subsequent finishing operations. The following three methods of forming represent good ball making practice:

1. Cold pressing for sizes smaller than 11/16 inch.
2. Hot forming for sizes from 11/16 inch to 1¼ inch inclusive
3. Forging for larger sizes.

For the purpose of illustrating the accentuation which takes place in seamy stock through forming, we will consider cold pressing as generally typical, although considerably more drastic than either hot pressing or forging. Our practice is to make ⅝ inch balls and those smaller on Manville headers. In this process the wire used for making the ball blanks is fed from coils resting on spindles into the headers and then passes through guide rolls into a quill from which it emerges in front of the "cut-off" blade. A wire stop determines the slug length. The "cut-off," shears the slug from the wire and is so constructed as to carry it over between the dies and as the "cut-off" withdraws, the plunger die approaches the stationary die compressing the slug into the form of a ball blank.

One can readily see that if the wire were seamy, the seam in the slug would be greatly accentuated in the ball blank. An example of this condition is illustrated in Fig. 1 which shows steel ball slugs partly and completely formed into ball blanks. The accentuated seam is readily observed in both. The diameter of the ball blank is 50 per cent to 60 per cent greater than that of the wire from which it was made. This operation is repeated at the rate of from 80 to 135 times a minute depending on the size of the balls being formed. It must also be remembered that we are cold upsetting a steel containing 1.00 per cent carbon and 1.00 per cent chromium, possessing an average Brinell value ranging between 175 and 200. We have found

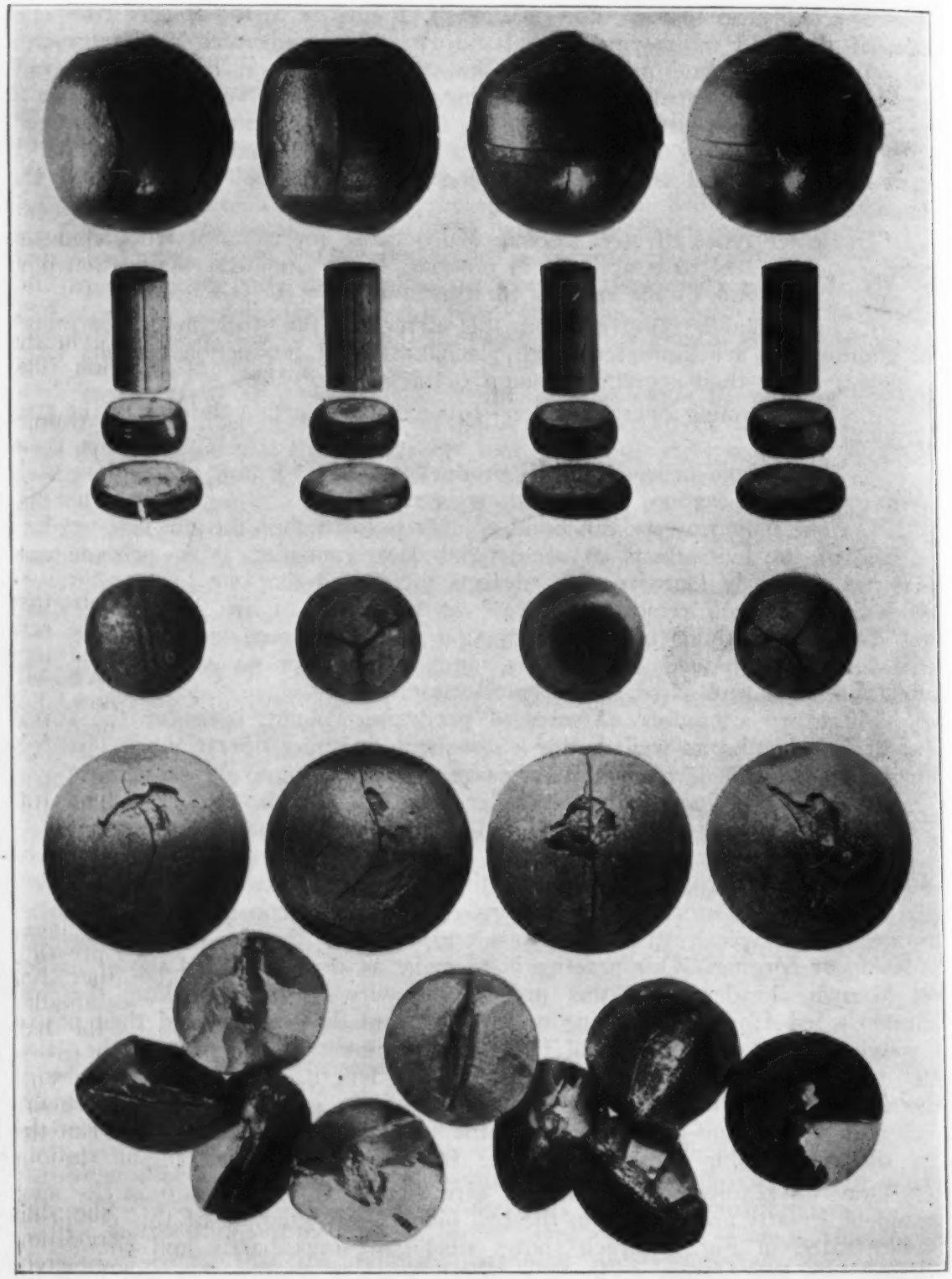

Fig. 1—The top row shows steel ball slugs partly and completely formed into ball blanks. The accentuated seam is readily observed in both. The second series shows two seamy slugs and two good slugs upset different amounts. The small balls across the middle of the figure are fire-cracked balls resulting from seams which were not completely removed before hardening. The large balls flaked in service due to unremoved seams. The pieces of broken balls at the bottom of the figure show a piped condition. Slag inclusions are noticeable.

that the accentuation of seams by this process varies greatly ranging anywhere from 1 to 5 times. Fig. 1 shows two seamy slugs and illustrates the manner in which seams are enlarged when the slugs are upset different amounts. With sound steel free from seams this crack would not occur.

In addition to the accentuation which occurs to seams we have also another factor to reckon with and that is the offset of the dies. Fig. 2 illustrates diagramatically this off-setting. Of course, this condition can be controlled within narrow limits but the dies in a header operating rapidly on this type of ball steel cannot be kept perfectly in line so we have to figure for a minimum ball blank diameter which occurs close to the portion of the ball we term the equator and is indicated as *B* on the diagram. The equator is the section of the ball where the flash is formed during cold pressing. The maximum cold working stress as well as the greatest accentuation occur at the equator, therefore we have the greatest defect in the headed ball at the point of least diameter. Thus a slight offset may cause the loss of balls that would otherwise clean up before hardening. In removing a defect it is necessary to grind off an amount of metal equal to at least twice its depth. This off-set of the dies is one of the factors which determines the permissible limit of decarbonization in the original stock of which the balls are made.

The next point for consideration is the manner in which seams become deepened during ball manufacture as well as the effects of decarbonization in the raw stock. After the ball blanks are formed they receive a rough grinding which removes the flash and most of the excess stock, they are then hardened. The balls produced from wire are given one heat treatment which is accomplished through a continuous process in rotary furnaces. At this stage of manufacture it is necessary that all seams and decarbonized metal be entirely removed, if not, the seams become accentuated again, frequently but not always producing fire-cracked balls. The situation would become much easier of solution if all the balls which possess remnants of seams at this stage would fire-crack, because they could easily be picked out after hardening, at some subsequent operation, or finally by the inspection department. We would then know that no future trouble would be experienced by exfoliation or by the breaking of balls in service. Fig. 1 shows several small balls which have been fire-cracked.

Tests for seams are made by cutting samples from enough coils to give a representative idea of the quality of each shipment. The test pieces are etched in dilute muriatic acid, either 1 to 1 or 1 to 3 parts of water, then rinsed in running water to free them from acid, and afterward cleaned with one of the ordinary kitchen cleaning compounds to remove any residue which may adhere to the samples. The test pieces are then dried and are ready for examination. This examination is performed by filing any seams that may be present until the bottom of the seam is reached. The depth is determined by use of a micrometer. The most accurate results are obtained by holding the samples in a vise, inasmuch as some of the seams are very fine and can easily be lost unless the filing is done in the most careful manner. These details of testing may seem most simple and yet nearly all of our disputes with the steel mills arise from a lack of strict adherence to the details of the operations just described. There are three types of seams which appear most often and are mentioned here without any attempt being made to explain their causes. All are equally serious to the ball maker.

Type 1. Are long seams of greater or less depth usually continuous

throughout the length of the section and occurring singly or in pairs and usually having complementary seams diametrically opposite. The two seams comprising each pair are parallel throughout their length but converge as they approach the center of the wire or rod. Fig. 3 in the upper left quarter shows a piece of bar stock which has seams characteristic of Type 1 and has been file tested as described.

Type 2. Are seams which may vary greatly in length or depth and also in their location on the bar. They may occur singly or a large number.

Type 3. Are seams which are always short, some of them not over ½ inch in length and of varying depth. These are found on both rod and wire but appear to be most serious on bar stock where they are found to be from 0.015 to 0.025 inch in depth or even greater.

No final inspection has been developed which is so perfect that it can be absolutely known that seams do not actually exist in the balls received by the customers when stock is used for their production which contains seams deeper than a certain limit. This is the reason that material used for ball

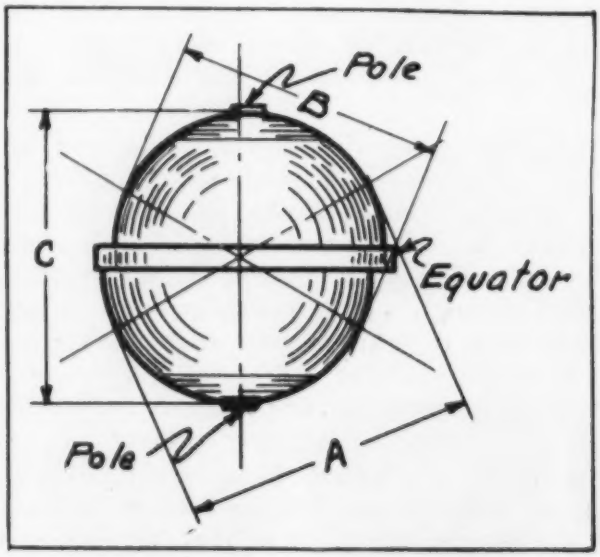

Fig. 2—Illustrating the off-set of dies resulting in a ball having a maximum and minimum diameter.

production is under such rigid restrictions against seams and the reason that it is rejected without allowance when the limits are exceeded. The specification states that no seams or surface defects of similar type should be present, but commercially, this is not possible of complete fulfillment. Our production methods indicate that 0.007 of an inch on radius is the maximum limit, while stock accepted usually possesses seams not exceeding half that limit, and in many cases ranging from zero to 0.002 inch only. Fig. 1 shows some balls that flaked in service. It will be noted that the flaking started from an unremoved seam in each case.

Let us now consider decarbonization limits. We require that at a distance of 0.004 inch below the surface, the stock must contain its full quota of carbon. In the lower right hand corner of Fig. 3 is shown three etched pieces of decarbonized wire. The plain gray wire *A* has the normal appearance of good stock while *B* and *C* are finely and coarsely mottled, respectively. This mottled condition generally indicates the presence of decarbonization. Wire like *C* usually has more decarbonization than stock

having the appearance of *B*. The lack of this peculiar surface condition, however, does not indicate that the material possesses its full quota of carbon as required. Where the decarbonization is quite bad it often manifests itself by a sparkling ring on the outer edges of the hardened test-pieces as is shown in the lower left hand corner of Fig. 3.

Balls will contain one or more soft areas, when made from wire possessing decarbonization to such a depth that it is not entirely removed from the minimum ball diameter before heat treatment. This depth of softness would be greater than the depth of decarbonization not removed, owing to the blanketing effect of the carbonless metal on the surface. Experience has shown that decarbonization on the surface of a ball, on account of this blanketing effect, produces, in some cases, a depth of softness at least several times greater than the actual depth of decarbonization present at this stage. This has been proven during production where soft spots were found in a given lot of balls.

For example, the depth of softness when discovered might range between 0.003 and 0.004 inch. At this stage of manufacture it would not be possible to remove much more of the excess stock before hardening and have the balls finish up correctly to size. In this event, hardening would be temporarily suspended on the lot in question while the balance of the unhardened balls would be sent back to the grinding room and 0.001 to 0.002 inch more would be removed. On being returned to the heat treating department and hardened it is usually found that all traces of surface softness have entirely disappeared although less stock than the depth of apparent softness has been removed and no changes in heat treatment have been made. It might be asked by some how we know that the balls which received the additional grinding originally contained decarbonized areas. The answer is that our experience shows that after a number of tests on the first portion of quantities of balls consisting of a ton or more, that they have agreed consistently, as to the precentage of soft balls after heat treatment.

There are two things of interest that might be mentioned here, and they also explain the reason we are compelled to inspect most rigidly and to reject on the limits given without any allowance.

1. When either seams or decarbonization are present they are not of uniform depth throughout the length of the coil or rod nor are they necessarily continuous.

2. That decarbonization when present will appear in two forms. In one type the surface metal will be composed almost entirely of ferrite possessing a more or less sharp line of demarcation at its junction with the metal having at least our minimum carbon allowance. The upper left hand photomicrograph in Fig. 4 shows the first type of decarbonization where the surface of the stock is almost entirely free of carbon. The stock is 0.365 inch wire as received in the annealed condition. The magnification is 75X, and the specimen was etched 40 seconds in a 3 per cent solution of nitric acid in ethyl alcohol. This type is easy to identify either by the microscope or the file test after hardening. The photomicrograph shown in the upper right hand portion of Fig. 4 shows a cross-section of 0.145 inch ball wire in the annealed condition as received. The mode of preparation of the micro-section and the original magnification are the same as for the previous picture. The carbon content of the metal contained in the first 0.004 inch taken off the radius was 0.51 per cent. This photograph illustrates the difference between the two types when viewed under the microscope.

A number of sections were examined under the microscope at higher magnification but it was difficult to identify the defective materials with any degree of certainty. This second type is more serious and is termed

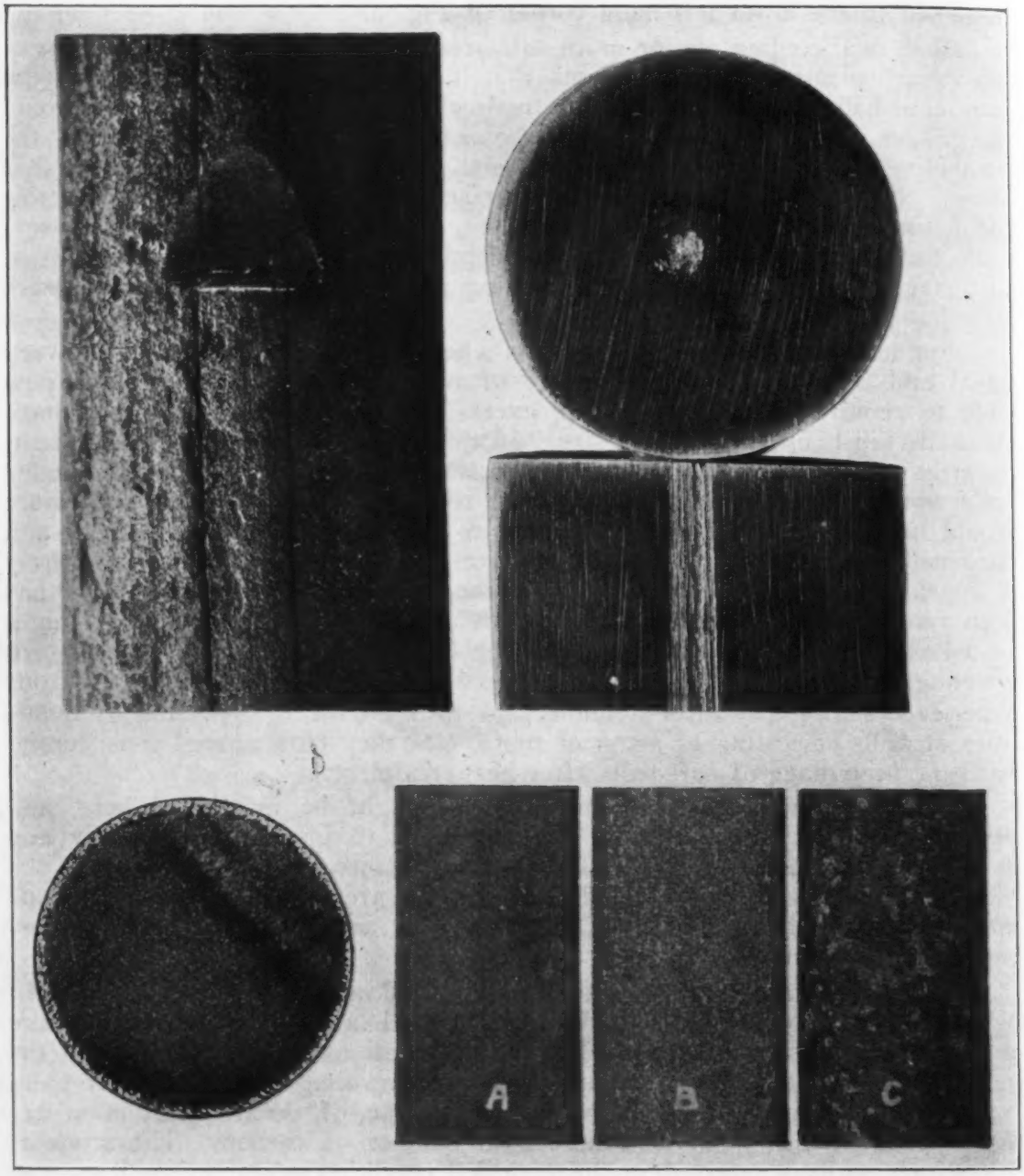

Fig. 3—In the upper left hand quarter is shown a piece of bar stock which has seams characteristic of Type 1. In the upper right hand quarter is shown two macro sections of a piped bar. The lower left hand photograph shows the sparkling outer ring on the edges of a hardened bar. This condition is due to decarbonization. In the lower right hand quarter is shown three etched pieces of decarbonized wire. Wire A has the normal appearance of good stock while B and C are finely and coarsely mottled. This mottled condition generally indicates the presence of decarbonization.

"graded decarbonization." All decarbonization is more or less graded but in this type it is accentuated. The surface of the metal may contain perhaps 0.50 per cent carbon, 0.004 inch farther in 0.60 per cent, 0.004 inch more may reveal 0.70 per cent carbon, and so on. Tables I and II

show the manner in which the carbon content increases as the center of the stock is approached, also that the quantity of carbon at any given depth varies greatly in different coils. This type also varies throughout the length of the coil both as to depth and continuity. It is very difficult to detect with certainty either under a microscope or with the file test after hardening. It has been found in hardening this type that the number of defective balls, that is balls showing one or more soft areas after heat treatment, may be decreased by the following methods:

1. Hardening additional times
2. By raising the temperature from which the balls are quenched
3. Quenching in water, if the balls are of a size which is usually quenched in oil
4. By tumbling after the first heat treatment in order that the scale formed thereby will be removed, and then giving the balls an additional hardening. All of these practices may tend to reduce the loss sustained by use of this type of metal, but it will be found that the only way to produce balls which possess uniformly hard surfaces is to reject this type of material when found, without making any attempt to use the stock by changing shop practice. The positive proof of the presence of this second type of decarbonization is by analyzing the different layers for carbon, but this represents a long job and is slow and difficult in cases where wires of small cross-section are tested.

The distribution of the decarbonized areas sometimes causes a great deal of difficulty when attempting to detect the presence of decarbonization in a given lot of wire. This condition is more serious when the decarbonized sections are of small size, often less than ½ inch in length and appearing on one side of the wire only, not necessarily around the section. These spots will appear at irregular intervals throughout the coil length but not necessarily on the same side of the wire. In the regular test for decarbonization we heat treat small sections of the wire without removing any of the surface metal, but when in doubt we remove the first 0.004 inches on radius from the wire being examined. In cases of the type in question we have found that small sections which would not harden correctly would be present even after the removal of the surface metal, before hardening, to a depth equivalent to our maximum permissible limit for decarbonization. Owing to the fact that these areas are so small it would be almost impossible to prove the existence of decarbonization by removing metal from the sections in question and analyzing them for carbon.

It can be deduced from the previous remarks that the microscopic examination of chrome carbon ball stock for the presence of decarbonization is not a reliable laboratory method for the protection of the customer against this type of defect. Decarbonization is tested in our laboratory by heating small samples of the wire in an electric furnace and quenching them in oil or water from a temperature which is a little higher than that actually required to produce the grain structure we desire in our finished product. This practice tends to eliminate disputes arising from the question of underheat, in cases where the presence of decarbonization is questioned. The test pieces are quenched from a metal tray in sets so as to produce uniformity and prevent any chilling effect of the tongs. The tray is supported above the bottom of the furnace to insure against any lack of uniformity in heating. The samples are quenched from a slow rising temperature while the heat treatment is recorded on a recordering pyrometer. Wire smaller

than 0.235 inches is quenched in oil which is at room temperature, while stock of larger section is quenched in water. At one time we had a dispute with a mill over a shipment of steel which we claimed would not harden satisfactorily. The mill contended that the temperature of the oil should range between 100 degrees and 140 degrees Fahr. as the increased con-

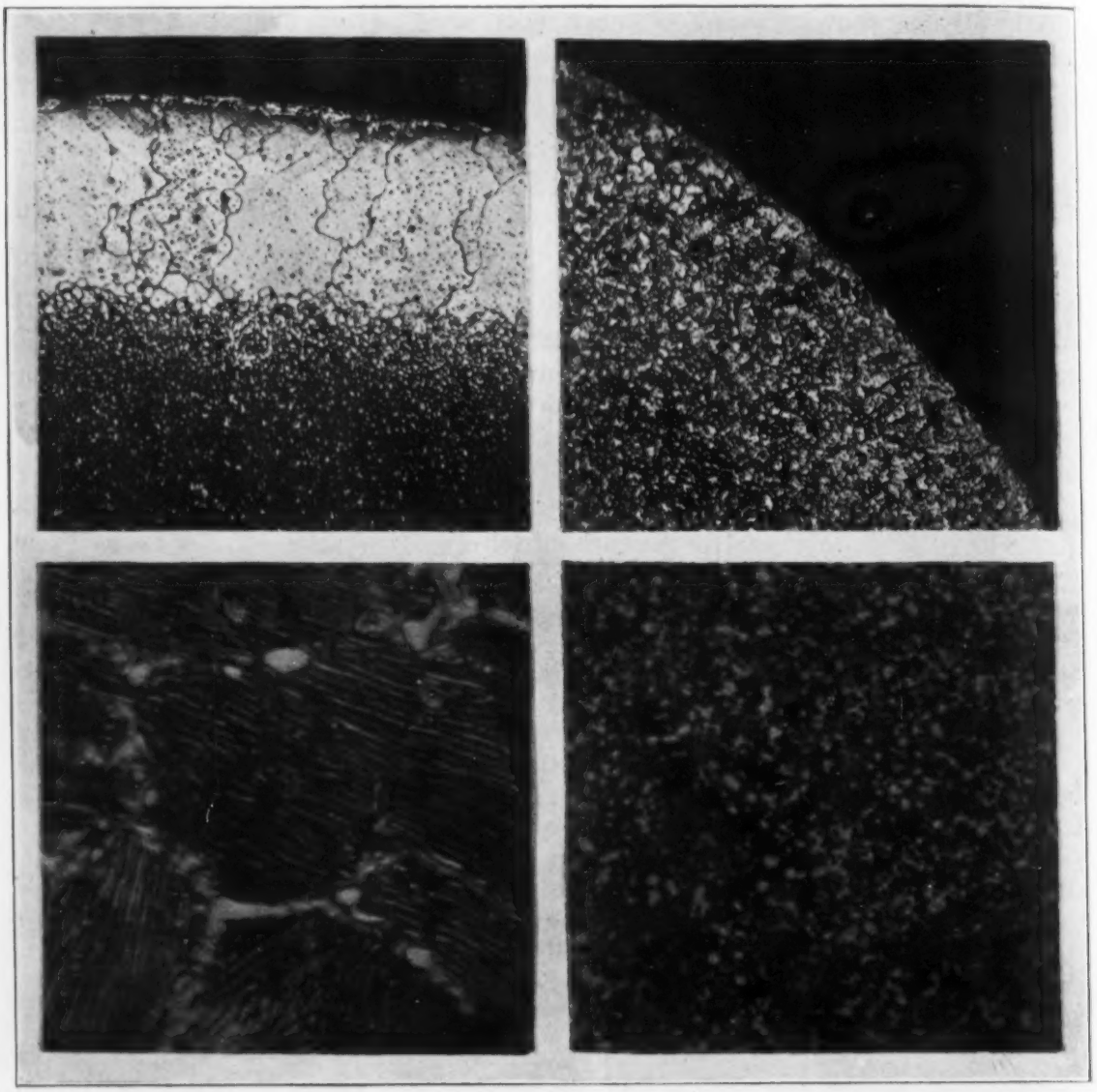

Fig. 4—The upper left hand photomicrograph taken at X 75 shows the first type of decarbonization where the surface of the stock is almost entirely free from carbon. In the upper right hand photomicrograph taken at X 75 is shown the second type of decarbonization known as graded decarbonization. In the lower left hand photomicrograph taken at X 1000 is shown a large grain structure bounded by carbides and accompanied with pearlite. This condition is due to faulty mill practice. In the lower right hand photomicrograph taken at X 1000 is shown the spheroidized structure which is preferred, having well dissolved and distributed carbides.

ductivity of the oil at that temperature would produce more effective hardening. One set of samples of the stock in question was quenched in oil at room temperature (approximately 75 degrees Fahr.) while the other set was quenched in oil at 120 degrees Fahr. If any improvement was present in the test pieces quenched in the hot oil it was not very marked, and certainly was not capable of convincing us that it was necessary to use heated

oil when hardening good ball steel. If the difference in temperature, of the range cited, would produce a marked effect in the hardness of ball stock, we would experience trouble more often in our regular hardening room practice on starting a furnace when the oil in the tank had dropped to room temperature than after the same furnace had run for a number of hours. This condition would become apparent to us when you consider that the balls are examined for what we term superficial softness, which means that the amount of softness when present will allow the operator to scratch the surface of a ball with a new file, but will not permit him to cut a small flat upon the ball. Considering the ideal shape of the surface of the ball for file attack, and the leverage which may be secured by use of a 10-inch file, you will perceive that the test is most severe from a hardness

Table I

Graded Decarbonization

Cut No.	Carbon Content per cent	Amount of Metal Removed from Radius
1	0.63	0.004 inches
2	0.67	0.004 inches
3	0.79	0.005 inches

Table II

Graded Decarbonization

Cut No.	Carbon content per cent	Amount of Metal Removed from Radius
1	0.47	0.004 inches
2	0.67	0.004 inches
3	0.83	0.005 inches
4	0.93	0.005 inches
5	0.99	0.006 inches

Cross section of wire as received contained 0.94 per cent carbon
Cross section of wire after 5 cuts contained 0.97 per cent carbon

standpoint. In all of the tests that we use we endeavor to have them approach as near as possible actual working conditions.

In the production, 5/16 inch balls, which correspond to 0.235 inch wire, also balls of smaller diameter down to 1/8 inch, they are quenched in oil. Sizes smaller than 1/8 inch are water quenched as are also those larger than 5/16 inches. We use only running city water in our water quenching operation. This applies to spheres 2 inches in diameter and larger. It might be mentioned here that our 2-inch balls are hardened almost to the center by this type of quenching.

In hardening from a rotary furnace, the balls are fed into a screened hopper which in revolving removes any steel dust or loose dirt that may be present, while at every revolution an adjustable bucket supplies the retort with a definite quantity of balls. The retort is made of a heat resisting alloy and has a spiral in its interior which causes the balls to travel to the discharge and where they slide down a short chute into the quenching bath. On entering the bath they are caught by a metal spiral which is enclosed with a heavy wire screen. They pass down this spiral to the bottom of the tank and are discharged into a wire basket 14 feet below the

surface. It is essential that the balls should not drop any great distance and collide with either themselves, the chute, or the quenching spiral, as at this stage some sizes have only from 0.003 inches to 0.004 inches excess stock, and the metal being more plastic while hot would flatten under the impact to such an extent that these flat areas would not be entirely removed in the finishing operations and would thus render the balls useless. The water used in the quenching bath flows outward from a tube in the center of the spiral; this tube having holes at several levels near the top supplies the coldest water where it is most needed. The behavior of the furnaces is indicated by recording pyrometers while a signal system consisting of a bank of lights informs the operators of their furnace conditions. The temperature is recorded from two points in the larger furnaces and is plotted as one curve by a two-point recorder. One point of each of the smaller furnaces is recorded and the position of the point is located slightly forward of the discharge opening. Gas is used for fuel and very little of the products of combustion enter the retorts.

Another very serious defect in ball steel are pipes. They prove very difficult for the ball manufacturer to guard against. In the upper right hand quarter of Fig. 3 is shown two macro-sections of a piped bar, one is a transverse section while the other is longitudinal, both from the same test piece. The piped condition is plainly visible in the center of each section. As a protection against this defect we break and examine the hardened sections of wire which were used for the decarbonization test. In the case of bars we grind the sawed ends of the samples and examine these. One coil or bar containing a pipe, is considered as sufficient cause for rejection of the shipment. This seems drastic, but when piped stock is formed into balls, unless the balls break in hardening as they often do, the subsequent grinding laps the metal over the pipes. The pipes then become very difficult to detect by our inspection department, especially on the smaller sizes of balls. At the bottom of Fig. 1 is shown pieces of broken balls which were piped. The included slag is readily discernible in several of the pieces. It will be noted that the piped areas are smaller at the ends than at the center and that the surface metal has been rolled over the ends of the pipes thus obscuring them.

In the case of wire it is necessary to specify Brinell hardness limits. These are 175 to 200 using a 1000 kilogram pressure and a 5 millimeter ball on account of the small cross section of the stock. The Brinell impressions are taken on the center of the transverse section and not on the outside. Cold upsetting a 1.00 per cent carbon, 1.00 per cent chromium steel at the rate of 100 per minute as a single stroke operation, is hard on dies, hence the upper limit. A lower limit is required because metal which is too soft tends to stick in the dies and does not shear satisfactorily. In shearing steel that is too soft the slug tends to bend a little too much just before the shear has completed its work. This causes a small piece of metal to remain protruding from the end of the slug and during the forming operation this is pressed into the ball. On subsequent grinding the lapped metal drops out leaving a cavity which is not removed during the finishing operation. In addition to this the slug tends to pass into the cavities at an angle which produces other complications, often resulting in damage to the machine.

The following points regarding size tolerance of raw material will be of interest. Wire up to and including 0.440 inches is ordered cold drawn to plus or minus 0.002 inches of a given size, and is supplied annealed to

meet our Brinell requirements. Rod for hot pressing is cold drawn to plus or minus 0.004 inches and is not annealed after cold drawing as this stock is hot sheared and hot formed. Rod for forging is given a tolerance which varies with the size of the stock, for example, bars under 1¼ inches in diameter are ordered minus 0 and within plus 0.012 inches. The diameter of the stock is considered as the mean of the largest and smallest diameters of the bar. In the case of wire and rod for cold and hot pressing, we find that when the stock has as little play within the quill as possible, we get the best results in shearing. Rods which are used for hot pressing require more play than wire which is fed automatically in the cold pressing operation. This is rendered necessary by the variations in expansion of the bars at different temperatures also on account of the stock being hand fed.

It is this relationship between quill clearance and correct shearing conditions that accounts for the close tolerance required in stock sizes used for cold and hot upsetting. On account of it being necessary to have this greater clearance in the quill used for hot pressing, we have increased slightly the tolerance of stock for hot pressing over that used for cold forming, thus reducing the cost of the raw material. Our experience has indicated that hand feeding stock when hot pressing is more advantageous than using the complicated apparatus which is necessary to correctly heat the rod, feed it into the machine, shear it, and form it into a satisfactory ball blank. Also, in the case of imperfect shearing or other accident, the stock can be more readily withdrawn avoiding damage to the machine. The machine that is used for hot pressing, forms at the rate of from 60 to 70 blanks per minute. In forging, a definite amount of stock is required to fill out the ball blanks. This explains the need for a zero minus tolerance, while stock carrying too great an excess on diameter produces an overfilled ball and the removal of this extra metal increases the cost of the resultant product. Stock for forging is supplied in multiple lengths which reduces loss through short ends. Rust or lead adhering to the surface of wire used for cold pressing is very objectionable as it gradually collects in the dies during the forming operation, producing a binding action on the newly formed ball blanks, thus retarding their discharge by the knockout pins. When this occurs another slug is fed over to the dies before the ball escapes and a "double-header," as it is called, is formed. This double-header often breaks the "cut-off" and frequently does other damage.

Occasionally we have trouble where the grain structure of the metal as received is too coarse. The ball manufacturer cannot afford to correct this condition, nor would it be wise for him to attempt it, even if it could be corrected, therefore we reject this type of material. This coarse grain structure is usually discovered in our laboratory tests at the time the stock is received. The appearance of the fractured ends of the heat treated sections used for the decarbonization test usually gives us a clue to the presence of this type of defect which is later confirmed by laboratory examination. With one exception this fault has appeared in wire sizes only. Balls made from this class of metal would not support their required minimum load at the heat treating stage, while the fractures would be coarse grained and dead. This condition is very rare and is usually accompanied by excessive decarbonization. The lower left hand quarter of Fig. 4 shows a photomicrograph of 0.365 inch ball wire. The large grain structure bounded by carbides also the accompanying pearlite is clearly defined. This steel apparently had been subjected to a very high temperature at the

mill, followed by very slow cooling. The magnification of this transverse section is 1000X. The steel is as received. The photomicrograph in the lower right hand quarter of Fig. 4 shows a transverse section of 0.320 inch wire, as received. The magnification is 1000X, the same as the previous picture. This is the spheroidized structure which we prefer, having well dissolved and distributed carbides.

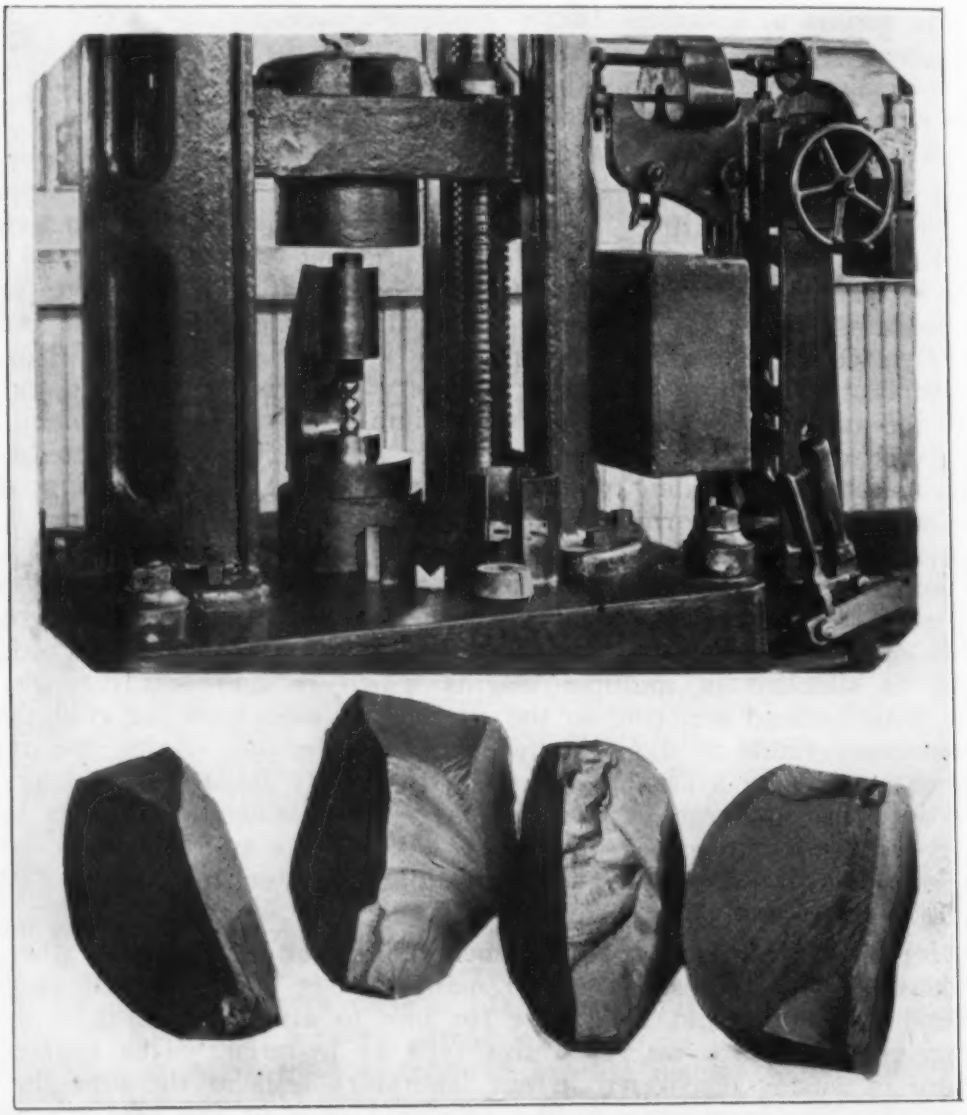

Fig. 5—Showing the jig used in the testing of balls when determining their crushing strength. Three balls are superimposed between a plunger and a supporting anvil. The pressure is applied by means of a universal testing machine. A number of fractured balls are shown below. The rugged appearance of the fractures and the fine, uniform grain structure are clearly defined.

Fig. 5 shows the jig used in the testing of balls when determining their crushing strength. The three balls are superimposed between a plunger and a supporting anvil. The pressure is applied through the plunger by a universal testing machine. Small V blocks are used to align the balls, while a guard placed around them protects the operator during the test. A number of fractured balls are shown below the testing machine. The rugged

appearance of the fractures and the fine, uniform grain structure are clearly defined.

In hardening balls we aim to produce a surface which will resist being attacked by a file, and at the same time, we endeavor to preserve the elastic properties of the metal so that the balls will render satisfactory service in bearings and not fail under varying stresses. No doubt, resistance to fatigue is also insured, to some extent, by the uniform surface hardness and its necessary accompanying uniformity of structure throughout the ball. In addition, the high degree of surface finish possessed by the balls probably aids materially, as well as the immersion in boiling water after hardening. This treatment in hot water has an ageing effect by providing an opportunity for the release of internal stresses. The fact that we have extremely few complaints where our best grade of balls are subjected to the most exacting conditions of service, appears to verify these conclusions. In case of question, we can identify the troostitic areas on the finished balls where very small sections of softness occur. Sometimes these small sections are no larger than the head of an ordinary pin.

The Brinell hardness value of the finished balls is in the neighborhood of 650, this value being determined by the use of a 10 millimeter ball under a 3000 kilogram pressure. The Brinell impression is made on a small flat of convenient size which has been ground on the hardened surface of the finished ball. The scleroscope hardness values vary with the mass and other factors, therefore it is necessary to refer to a plotted curve in order to determine the correct value for a given size of steel ball. Sometimes we meet with hard sections in the wire coils. They are difficult to find in the laboratory examination of the shipment and are probably due to some fault at the mill which produces a lack of uniformity in the annealing operation. A great deal of trouble is experienced when coiled wire contains hard spots. Quite often these extremely hard sections fail to shear correctly and sometimes they do not shear at all but simply break off in a very irregular manner. When wire breaks, instead of shearing, the lack of uniformity of the operation will cause the slug to be carried over between the dies at such an angle that serious damage is done during compression. A slug made from wire which breaks will not make a good ball because cavities will usually be present at the poles of the finished ball owing to the irregularity of break at the original slug ends.

In conclusion the writer desires to say that he realizes that a great deal more can be said regarding the requirements of good ball steel, but has only attempted to cover at this time, in more or less detail, the problems which most frequently confront the ball manufacturer when purchasing steel for the manufacture of a product which is expected to fulfill the most exacting requirements during service.

Discussion of Mr. Freeland's Paper

MR. DANSE I want to compliment the speaker on his clarity of speech. I do not think we could have gotten anybody to explain this or any other problem in better English or in a better manner. I want to thank Mr. Freeland on behalf of the Society. It is a very interesting subject to all of us, I am sure. Are there any questions you would like to ask him regarding this subject? He came very near telling it all but maybe he has not. One thing I would like to ask him is regarding service of balls for Brinell ma-

chines. Is it possible to insure service of 10 millimeter steel balls in Brinell service on hard parts which run in the neighborhood of 500 to 520?

MR. FREELAND That is a proposition we have been working on for some time. We have endeavored to procure a steel which would be satisfactory when testing hard materials where the hardness values range anywhere between 500 to 700, or a little more. The difficulty is in procuring a type of stock which when hardened will possess enough excess hardness over the material under test. We are using at the present time a steel containing tungsten with a high percentage of carbon. During the war, Government inspectors at our plant claimed that the Brinell balls made from this steel would give a service of 200 tests as against the regular chromium steel ball which had previously been supplied and which they rejected after being used for about 40 determinations. Of course, the great difficulty to be overcome is the deformation which takes place in the Brinell ball and this is variable. We have no way of controlling this except by procuring a type of stock which will become extremely hard when correctly heat treated. In fact, we sacrifice somewhat a fine grain structure and incidentally some of the resistance of the balls to shock in our endeavor to produce a superhardness. This special Brinell ball is about 50 points harder than the regular chromium steel ball of the same size and is certainly a great deal tougher. I realize this is a very important problem. If anyone in the audience has any suggestions to give with reference to a steel that will be superior to the one we are using the speaker would be glad to hear from him.

UNANNOUNCED SPEAKER In the last paragraph I believe you said that the difficulty of the broken end was what spoiled the ball rather than the brittleness of the material.

MR. FREELAND I was considering the matter from an inspection standpoint. Supposing that the ball would otherwise be alright, it is defective from the beginning by the fact that there are cavities at the ends of the ball owing to the irregularity of break. This would cause its rejection by the inspection department. Sometimes the wire is brittle but will still shear. If this brittleness was caused by a slight irregularity of mill anneal or in drawing and the grain structure is not too coarse the subsequent heat treatment which it receives at our plant would correct it. Usually the hard spots are not long and most usually appear on one side of a coil.

UNANNOUNCED SPEAKER Would that also apply to the irregularities you found in decarbonization?

MR. FREELAND I think so. Of course, I am not at the mill, and in talking about a plant at which you are not located you do not know the fine details. The manner in which the decarbonization is distributed and from its irregularity of occurence in a given shipment I would say that it may be caused in some cases by overheating the stock for rolling or in the normalizing and annealing operation of the rods before cold drawing. It seems to me that when the graded condition occurs a small amount of carbon is first removed and later more carbon is removed from the surface with an accompanying diffusion of carbon from the section of higher carbon content toward the surface. The result is thus cumulative and over a period and varies greatly. One coil may contain the required carbon content, say within 0.008 inch of the surface and the next test piece of presumably the same heat treatment and anneal will require the re-

moval of 0.020 or 0.030 inch before sufficient carbon is reached.

MR. WEBSTER Why is water quenching used for the two extremes and oil for the medium size?

MR. FREELAND In the case of balls which include sizes from 5/16 inch down to 1/8 inch we find the oil quench most satisfactory because we obtain the necessary hardness and other required properties without resorting to a water quench which is more drastic, while with the smaller balls we are unable to obtain a uniform quench in oil because of the lack of uniformity in the loss of heat which occurs in these extremely small masses of metal during the transference of the balls from the heating element to the quenching medium. This is not done automatically as is the case with larger sizes but the balls are heated in nickel-chromium tubes submerged in a lead bath and are then transferred to the quenching medium by inverting the tubes. Water being more drastic than oil as a quenching medium compensates for the loss of heat referred to. The larger sizes we quench in water to obtain the necessary penetration of hardness and this with the increased chromium content used in larger ball sizes produces spheres of uniformly high load carrying capacity and endurance. We attempt to quench steel of the right chromium content in such a manner as to produce a ball of the required strength and surface hardness without unnecessary sacrifice of the elastic properties.

MR. WEBSTER I was wondering if the small balls did not show more defects.

MR. FREELAND The small balls show less defects mainly because the drawing at the mill tends to eliminate both decarbonization and seams by reducing their depth. As an illustration, a short time ago we rejected a shipment of 0.365-inch ball wire on account of the presence of a small amount of decarbonization. The mill in question asked if we would be willing to have them take the material back and reduce it to 0.320 inch or a size smaller in order to reduce the depth of decarbonization to an amount within our permissible limit. We agreed that this would be satisfactory but the defect would have to be eliminated. We have less loss through fire-cracked and part soft balls on small stock than on large for that reason.

MR. DANSE Would you mind telling us something of the class of steels used for header dies?

MR. FREELAND The die steel proposition is a serious affair with us because it affects the rate of production and on account of die cost. We have tried nearly all steels including a number of freak steels and found straight carbon steel ranging from 1.00 per cent to 1.10 per cent far superior to any of the alloys including vanadium, chrome vanadium and others of those alloys which you might think would be satisfactory. We have found crucible die steel which has been hammered in two directions and rolled to a round of required size superior to the same type of steel where the stock has been upset. We could probably use a little lower carbon, perhaps 0.90 per cent to 0.95 per cent except for the fact that our die cavities are small, thus rendering it very difficult to get the depth of penetration required at the bottom of the cavity. Many steels that appear to have worked for other people have not stood up for us.

With reference to shearing blades, I might say that we use a steel con-

taining between 12 per cent and 14 per cent chromium, heat treated by quenching in oil from a temperature from 1650 degrees Fahr. to 1700 degrees Fahr. I thought at one time that this temperature was a little excessive so we tried about 100 degrees lower but it did not make any marked difference. We get excellent results at that temperature, therefore, we did not make any change.

MR. WEBSTER May I ask if there is a marked difference between the cold pressed as compared to hot pressed balls?

MR. FREELAND I can answer a part of your question and a part I cannot answer. The weakest line of a ball is along the line of original rolling of the stock. When we upset the ball we tend to destroy that structure somewhat, but nevertheless, when the plane of applied pressure is across the end grain of the stock and not in a line with it the ball supports the greatest load. There is not a great deal of difference but there is some. I do not believe there is a marked difference between hot pressed balls and those which have been cold formed. If the subsequent heat treatment would remove the effect of original working at the mills we would not expect to find any difference in the balls whether compressed through the equator or in a line with the poles. In hot forming the stock is heated up to about 1800 degrees Fahr. and then worked. If the heat treatment the cold headed balls receive does not remove the effect of original rolling even after the steel has been upset into the form of a ball blank it is not likely that the hot pressing operation would produce a different result. There is one marked advantage in hot pressing over forging and that is that the metal in hot forming is not heated to the high temperature which is usually used in forging and the finishing temperature is much closer to the critical point of the steel. The internal strains arising from cold pressing are greater than those from hot pressing but in both cases these are relieved by the subsequent heat treatment, while after being quenched, the balls are immersed in boiling water for at least one hour and this tends to relieve the hardening strains without affecting the surface hardness of the balls. The crushing pressures of our cold and hot formed balls conform to the same formula.

UNANNOUNCED SPEAKER I would like to ask Mr. Freeland how he quenches the dies, especially the surface where the heading is done, where the enormous pressure comes in the process of forming.

MR. FREELAND If we had a blackboard I could show you. The quenching jig is shaped somewhat like a cup with water coming up through the center while the die rests in this cup supported by a small ledge of metal, most of the die face being exposed to the action of the quenching medium. At the bottom edge of this cup are holes for the escape of the excess water while the pressure used is sufficient to drive the water through the cavity and up through the knock-out pin hole thus eliminating any possibility of a gas pocket. The cold water runs continuously. It will be seen that the preferential quench is at the cavity. This is the most successful method that we have found. We have tried quenching by complete immersion in water but in this case the cavities were not hard enough.

We at one time prepared a jig by means of which the dies could be completely immersed in running water while a preferential quench was given to the cavity itself but this was not satisfactory. The dies appeared to be too hard and would chip or break. The jig was constructed of four rods joined by a circular section of metal at the top and bottom. The rods

were equally spaced and were far enough apart to accommodate the die being quenched and were about 30 inches long. This jig was immersed in a tank of running water while a pipe which conveyed a stream of water under high pressure was projected into and centered in the bottom of this jig. In order to quench the dies it was only necessary to invert them and place them in the jig down which they would pass until they came in contact with the pipe at the bottom. By this means a stream of water would be forced through the die cavity and knock-out pin hole, while the balance of the die would receive a complete quench owing to its immersion.

With further reference to the composition and type of die steel used in heading I would like to say that on two occasions we made service tests on 1.00 per cent carbon, 0.2 per cent vanadium steel and much to our surprise the average life was about 25 per cent below straight carbon steel. We have also tried upsetting dies. We procured a block of steel and upset it, in our endeavor to avoid the porous condition at the center of the die stock. At another time we cut the dies from the side of a block of steel. This permitted us to sink the die cavities across the grain instead of with it. We found that our results in both cases were about the same as when vanadium was present, namely three-fourths of our normal die life, causing us to draw the conclusion that a satisfactory die for our purpose should have its length conform to the direction of the original working of the metal.

UNANNOUNCED SPEAKER About how many balls do you get out of an average die?

MR. FREELAND An average die will produce from 30,000 to 50,000 balls of ½-inch diameter.

MR. WEBSTER How do they fail?

MR. FREELAND They fail by two methods. In one case the cavity of the die at the point of contact of the slug, checks; in the other case, their failure is caused by the cavity sinking under the impact.

MR. WEBSTER Have you attempted to rework these dies and do they last longer after reworking?

MR. FREELAND We rework them except in cases where they crack.

With reference to the life of a die after being reworked, I do not believe there is much difference. When dies fail, the failure usually occurs during the first 20 minutes of service.

MR. WEBSTER Do you find a wide variation in the production of dies made from the same bar of steel?

MR. FREELAND I would say yes. Sometimes it is more marked than at other times. I think that one of the reasons why the die probably fails so quickly is because the cavity is sunk in the weakest part of the section where the most porosity exists; namely, the center of the bars.

MR. WEBSTER Do I understand that you run these dies in relays?

MR. FREELAND We usually run the dies until they fail or require redressing, except when changing to another ball size.

MR. WEBSTER I was just wondering if it was a fatigue test.

MR. FREELAND Yes, it is practically a fatigue test because they are usually run to destruction.

MR. WEBSTER About what Brinell hardness do you use?

MR. FREELAND The scleroscope hardness at the cavity is in the neighborhood of 85. I do not know the exact Brinell value.

MR. WEBSTER Have you experienced any difference in the quality of the ball where you use different heading rates?

MR. FREELAND The only way that I can answer that question is to say that a 5/8-inch ball is formed at the rate of about 80 a minute; the smaller sizes, say from 1/4 inch to 1/8 inch, at about 135 a minute. We require a minimum crushing pressure in the hardening room test of heat treated balls and the same formula applies to all sizes between 1/8-inch and 1 1/4-inch balls, and all balls which are released must meet this requirement, so I do not believe that the rate of upsetting, within the limits we use, affects the quality of the ball.

MR. WEBSTER I presume the number of diameters you have in the slug to upset would have something to do with it.

MR. FREELAND Yes. The finished ball diameter is about 55 per cent greater than the diameter of the slug from which it is made.

MR. WEBSTER The number of diameters would have to be approximately close to two, I imagine.

MR. FREELAND I could not say exactly. We have determined a series of slug lengths for different sizes which will feed correctly and press well without buckling, etc. I would say that the factor is probably two to two and one-half times.

MR. WEBSTER Does your experience in forming this wire indicate that the flash is more pronounced on one side than on the other?

MR. FREELAND No. Usually the ball blanks are well balanced. Any case where the flash is more pronounced on one side than the other would be caused by displacement of the dies. A number of things might produce this, for instance, stock of irregular hardness would tend to shock the machine in such a manner as to displace the dies slightly.

MR. WEBSTER Sometimes in drawing wire the radius of the drawing die is eccentric to the hole of the drawing die, and it gives you eccentricity of draw, and for this reason the wire is of different hardness on one side than it is on the other. I was just wondering if this made enough difference to affect ball production.

MR. FREELAND I have no reason to believe that it does. I believe the trouble we experience from hard sections in the wire is of different source.

UNANNOUNCED SPEAKER I would like to ask the gentleman what his idea of a good steel for headers is.

MR. FREELAND The header man is looking for a steel that will stand a tremendous amount of shock. The die cavity has to resist the tendency toward distortion in service, which is quite great. The die should not break under impact, neither should the cavity crack, check or sink, and the bottom of the cavity at the junction of the knockout pin hole must not peen over in service. A straight carbon steel most closely meets these requirements.

UNANNOUNCED SPEAKER Mr. Chairman, I would like to ask the speaker just what is the manner of ball inspection?

MR. FREELAND The balls are inspected by visual examination, that is, the balls which are sent to the customers to fill their orders. They are examined on plates equipped with special reflectors arranged in such a manner as to counteract the glare caused by the bright light shining upon the mirror-like surface of the balls. The balls are revolved by moving a flexible card upon which they rest, thus exposing all parts of their surfaces

to view. The girls who do this work become very accurate in identifying balls having soft sections, seams, laps, or any defects. It takes six months to train a girl for microinspection, that is, a girl who is capable of inspecting our highest grade balls without the necessity of having her work continually checked. The way we maintain our standards is by the laboratory checking every day the different sizes of balls being inspected. The examination in this case is chiefly for concealed defects, that is, defects in the ball which are not visible to the inspector. The surface hardness, crushing loads and fractures are also checked at this time.

UNANNOUNCED SPEAKER Do the soft spots show up in a visual examination?

MR. FREELAND Yes. They show up in two ways. In one case the soft areas have a battered appearance, while in the other case the color is different. A soft spot on a ball is usually a darker color than the remainder of the highly polished surface. Possibly it is the troostitic condition of the steel at the point of softness that makes it actually darker.

MR. DANSE Is that 100 per cent inspection on each and every ball?

MR. FREELAND Yes.

MR. DANSE Do you use the bounce test for hardness?

MR. FREELAND No. The only time when this apparatus is used is when somebody in the plant accidently mixes hard and soft balls and it is necessary to separate them. This test is very interesting and possibly something could be developed from it. During the war it was necessary to furnish a few thousand balls which had to be super-hard. As I remember it, the ball size was ½ inch. Our regular balls passing through production were of such uniform hardness that ordinary inspection methods would not differentiate between balls which were slightly harder than our normal stock. In this case we used the bounce test by means of which we were able to separate accurately balls which were two points, scleroscope, harder than their fellows.

In this test the balls roll down a groove from which they drop to a hardened steel block and bounce from there over a hurdle-like arrangement into a box. Only the hardest balls are capable of passing over the hurdle. We found after we had bounced the balls six or seven times that all balls with soft spots were removed, and we were unable to determine the existence of any difference in the remaining balls by use of the scleroscope.

Comment and Discussion

Papers and Articles Presented Before the Society and Published in Transactions Are Open to Comment and Criticism in This Column—Members Submitting Discussions Are Requested to Give Their Names and Addresses

A DISCUSSION OF LANCELOT W. WILD'S PAPER ENTITLED "THE INFLUENCE OF HEAT TREATMENT UPON THE MAGNETIC PROPERTIES OF STEEL"

By N. J. Gebert

MR WILD states that the measurement of permeability and residual magnetism cannot be measured accurately except in ring form, or very long rods, which must be measured in pairs. The writer wishes to call attention to the fact that the latest developments of magnetic testing prove that this can be done on single specimens not in ring form, and also on almost any length. Scientific Papers of the Bureau of Standards No. 306, entitled "An Experimental Study of the Fahy Permeameter" is quite descriptive of an outfit which will make permeability and residual magnetism tests. Since the publication of this paper, the Fahy Permeameters have been further developed, and absolute accuracy can be obtained. This latest development of magnetic testing shows that accuracy can be obtained on material of the highest permeability and materials of low permeability with no change in the set up. This applies to the best Norway iron, silicon sheets for transformers, and electrolytic iron.

The writer is at a loss to account for the values of magnetic intensity which are shown on Table II. In my paper, printed in the *Journal of the American Steel Treaters' Society*, June, 1919, to which Mr. Wild refers in his bibliography, there is a direct comparison on the same kind of steel. I refer to nickel steel of 0.42 per cent carbon and 3.58 nickel. Mr. Wild shows reading of magnetic intensity of 20.7 with the draw 100 degrees Cent., a reading of 20.75, with a draw of 200 degrees Cent., whereas measurements which I have made show a reading of 17,000 Gauss per square centimeter at 100 degrees Cent. draw, and 19,900 with a draw of 200 degrees Cent. Also at draw of 300 degrees Cent., Mr. Wild shows a reading of 20.9, whereas I attained 20,050. It would, undoubtedly, be very difficult to observe the small differences of magnetic intensity which Mr. Wild shows, as the results which were shown in my method of testing, using the Fahy Permeameter, give much greater differences.

Mr. Wild further states that the galvanometer employed was not sufficiently sensitive to bring out the changes that really occurred in the coercive force of iron. This may account for his very slight differentiation in the magnetic intensity at various drawing temperatures, as the outfit which I employed was sensitive enough to test the coercive force, permeability, residual induction, etc., of any magnetic material.

A written discussion of Lancelot W. Wild's paper presented by title at the Indianapolis Convention and published in TRANSACTIONS May 1922. The author, N. J. Gebert, is metallurgist, American Chain Company, York, Pa.

Mr. Wild's results on the values of coercive force—Table III—agree very closely with the results which the writer obtained. Therefore, I am at a complete loss to understand his readings on magnetic intensity, unless Mr. Wild's outfit, particularly the galvanometer, is not sensitive enough to record accurately the slight differences in magnetic intensity.

AUTHOR'S REPLY

Mr. Gebert is a strong advocate for the Fahy permeameter. Though I admire the ingenuity that has been displayed in the development of this apparatus, yet I am sorry to be unable to endorse Mr. Gebert's good opinion of it when applied to heat-treatment problems.

I know the Fahy permeameter. The Bureau of Standards have very kindly kept me supplied with all their publications from the commencement (for which I am really grateful), and as I have been rather specializing in magnetic testing for more than twenty years, I have naturally followed with keen interest all developments of this nature.

Like most other magnetic testing apparatus, the Fahy permeameter suffers from the disability that the liability to error increases as the length of the test specimen is decreased. Frankly I should consider it beyond my powers to obtain systematic accuracy on test pieces measuring 1 x ¼ inches with the Fahy apparatus.

For the investigation of the "why and the wherefore" of steel hardening I have so far found that the measurement of saturation intensity has proved the most fruitful in results. For this measurement I require to employ short specimens. If on the same test pieces I could obtain the permeability at 1 or 2 points on the magnetization curve and the residual magnetism as well, I should certainly like to have them, although I do not at present see what would be gained. I do not, however, see my way to obtaining the precision required without materially lengthening the specimens.

Mr. Gebert appears to be surprised that when measuring inductions in unsaturated steel, he obtains values over a wider range than I obtain for measurements of saturation intensity. This appears to me perfectly natural.

With unsaturated steel the flux density depends upon two factors, namely, the ultimate magnetizability of the steel, and the mobility of the molecular magnets (a vile phrase but orthodox).

My measurement of saturation intensity implies the magnetizability of the steel alone and undiluted. It appears to me the better plan to measure ultimate quantities singly when one can do it. Mr. Gebert's permeability measurements really require analysis into their two components, an analysis which no one has yet succeeded in effecting.

In short, I am not out to obtain haphazard value ranges only, but to obtain values which can be reduced to fundamentals and employed for the purpose of analysis, the ultimate goal being a complete explanation of all the structural changes that take place in steel when heated and quenched under all sorts of conditions.

Since my paper was written about a year ago, I have made considerable advances in this direction, but I am not yet quite prepared to face destructive criticism of my analytical methods.

Mr. Gebert appears to have rather missed the point in his reference to my tests on iron. The tests for saturation intensity were carried out with the utmost care and very high precision, it being particularly desired to ascer-

(*Continued on Page* 928)

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

NEW QUESTIONS

QUESTION NO. 32. In choosing a carburizer, what are the essential features that should be considered?

QUESTION NO. 33. What is the role of nickel in steels?

QUESTION NO. 34. What is meant by the critical range or transformation range in a steel?

QUESTION NO. 35. What is the difference between red annealed and blue annealed sheet steel?

QUESTION NO. 36. Can mixed lots of steel be identified with a certainty by the aid of the grinding wheel spark test?

OLD QUESTIONS AND ANSWERS

QUESTION NO. 8. What is the effect of high and low silicon in tool steel?

QUESTION NO. 10. What surface of steel, that is, machined, cold rolled, hot rolled or cold drawn, carbonizes fastest and why?

ANSWER. By W. S. Bidle and B. F. Weston. Although experience had shown that there should be little if any difference in the rate of carbon penetration when treated under the same conditions, on the same steel whether it be cold rolled or drawn or hot rolled or machined condition several test pieces were submitted to a carburizing treatment, to check up this assumption. Mr. Weston, metallurgist of the Union Drawn Steel Company, reported the results of his tests as follows:

Steel specimen No. 1 was a 13/16 inch round hot rolled bar which was drawn to ¾ inch in diameter having a carbon content of 0.20 per cent and a manganese content of 0.47 per cent.

Steel specimen No. 2 was of the same size as No. 1 having a carbon content of 0.21 per cent and a manganese content of 0.58 per cent and a nickel of 3.38 per cent.

Steel specimen No. 3 was of the same size as the first two and of the ordinary screw stock analysis.

Before drawing steel No. 1 the hot rolled bar was pickled to remove scale. Each of the specimens were cut 4 inches long and were packed in a car-

burizing material made by a well known company allowing 1 inch of material between the side of the box and between each specimen. The box was placed in the heating furnace with a pyrometer thermocouple nearly touching the box and was heated for 4¼ hours from the time it had reached 1700 degrees Fahr. The box was allowed to cool in and with the furnace.

A section ½ inch thick comprising ½ the area of each bar was polished and etched and the depth of penetration was measured by means of a micrometer microscope at a magnification of approximately 27 diameters. The following results were obtained:

Steel No. 1 Hot Rolled depth of case	0.033 inch
Steel No. 1 Cold Drawn depth of case	0.034 inch
Steel No. 2 Hot Rolled depth of case	0.044 inch
Steel No. 2 Cold Drawn depth of case	0.047 inch
Steel No. 3 Hot Rolled depth of case	0.034 inch
Steel No. 3 Cold Drawn depth of case	0.037 inch

These measurements were made by two observers and it will be seen that a very slight difference if any, was observed in the depth of the case between the hot rolled and cold drawn specimens.

Mr. Bidle reports the result of a similar test which had been made in his plant on some Bessemer screw stock. The specimens had been prepared by taking the end off of the bar after being pickled and the adjoining end off of the same bar after it had been cold drawn. One specimen was left as pickled, one pickled bar was turned, one bar was left as cold drawn and the final piece was turned down slightly after cold drawing.

All of these specimens were packed in the same carburizing box heated to the carburizing temperature and cooled in the box and subsequently all four pieces were heated side by side and quenched.

As there were no accurate means available for measuring the depths of case of these specimens, they were visualized by several different observers and in all cases the depth of penetration appeared to be identical.

This result checks up many years of experience in practical carburizing and heat treatment and appears to be the results which have been obtained by many other observers. Therefore we believe that there is very little if any difference in the rate of penetration on bars having different mechanical treatments.

QUESTION NO. 12. How and why is cast iron heat treated? Is there such a process as ageing or seasoning castings other than by annealing?

QUESTION NO. 23. Why is it that a piece of hot rolled steel, of a given composition, will not harden in oil after carbonizing to the degree that a piece of the same composition will if first subjected to forging?

QUESTION NO. 24. Do steels of similar composition respond similarly to case hardening operations, and providing these are properly conducted, will satisfactory results always be obtained?

ANSWER. This question is answered quite fully in a paper presented by E. W. Ehn at the annual meeting of the Iron and Steel Institute in May, 1922. This paper shows that certain steels although complying in all respects with the usual specifications regarding chemical and physical properties, are quite unsuitable for carburizing.

One of the chief causes for the failure of steel of the low carbon content to harden after it has been carburized, is due, to improper deoxidization of the steel during melting. While the usual specifications for carburizing steel are as follows:

	Per Cent
Carbon	0.15 to 0.20
Manganese	0.35 to 0.65
Phosphorus, below	0.040
Sulphur, below	0.040
Silicon	0.005 to 0.010

there is no mention of the oxygen content. The degree of deoxidization of the steel affects directly all of the important factors which contribute to a properly carburized steel, such as maximum carbon content, depth of case, structure of the case and core and the way in which the carburized piece responds to final hardening.

An extensive examination was made in an effort to determine the conditions which frequently caused the rejection of carburized parts, due to soft spots even after extreme care had been exercised in carburizing and hardening. At first these failures were attributed to improper carburizing and hardening practice but later was definitely determined as due to an inherent property in the steel itself.

Further investigation proved that the difficulties were traceable to the ingot and that the cause or effect of the difficulty was not removed in any successive operations or treatments. It was found that the presence of soft spots in the steel was always accompanied with a special fine-grained structure in the carburized part. Steel showing such a characteristic would be classed as abnormal although it apparently was of the same composition as a steel having a uniform hardness after the same treatment. Poorly or insufficiently deoxidized steel while having apparently the same composition as a well deoxidized steel will give erratic results and almost always produce soft spots in the final product.

QUESTION NO. 25. What is the difference between magnification and enlargement in taking photomicrographs?

ANSWER. By Walter M. Mitchell, Philadelphia, Pa.

In the customary use of the word "magnification" we refer to the direct magnification (apparent increase in size) of the object examined. If recorded by photography the magnification represents the number of times that the photographic image of the object is larger than the object itself. This is al-

ways considered in linear dimensions; i. e. diameters, and not in areas. The greater magnification, the smaller the details of the object that will be made visible until the limit of resolving power is reached, after which no further details will be made visible no matter how much the magnification is increased. The resolving power is the ability to separate and render distinct; i. e. to "resolve" the finest details of the object. It depends upon the physical properties of light and the constants of the microscope and is independent of the object itself. "Enlargement" as ordinarily used means enlargement, or magnification, of the photographic negative. Such enlargement can show only such details as are actually on the photographic negative. Due to the fact that the grains of metallic silver of which the photographic image is composed have a finite size there is a practical limit to the degree of enlargement which it is advisable to make. This will probably be about 7 to 10 times; above this the silver grains become conspicuous and give the resulting photograph a granular appearance. Briefly, increased magnification will show finer details of the object itself, while enlargement can show no other details than those already on the photographic plate.

QUESTION NO. 26. Does the presence of pearlite in the decarburized zone of a malleable iron casting effect the resistance of this casting to shocks?

QUESTION NO. 27. What is the function of the high phosphorus and the high sulphur content in the so called automatic screw stock steel?

QUESTION NO. 28. What is the role of manganese in steel?

In addition to the deoxidizing effect and also the desulphurizing effect of manganese in ordinary steels, wherein considerable of the manganese combines with sulphur forming MnS it is found that when manganese occurs in excess over the amount that is needed to form MnS with the sulphur content present, the excess manganese combines with some of the carbon forming Mn_3C and this carbide is found associated with iron carbide Fe_3C, in cementite. The prime effect, therefore, of manganese subsequent to its beneficial assistance in melting, is its effect upon the mechanical properties of steels. These effects pertain to varying percentages of manganese and are believed to be primarily due to the retarding action of this element on the transformations and on the coalescence of the micro-constituents into progressively coarser masses, which while increasing the ductility it lessens the cohesion in general, including the hardness and elastic limit, and thus lessens the effective strength.

Manganese like most of the alloying elements such as carbon and nickel retard the transformation of steel in heating and cooling. In a steel containing 2 per cent manganese with 2 per cent carbon the transformation is so retarded the austenitic state is preserved when quenching thin sections. In a steel containing from 5 to 7 per cent manganese the transformation is so slow that even air cooling only goes as far as the intermediate martensitic state, which accounts for the brittleness of steels containing an intermediate amount of manganese. With a 12 to 13 per cent manganese content the transformation is so slow that the austenitic state is preserved through slow cooling. Water quenching of a manganese steel of this composition is done for the purpose of suppressing the precipitation of the iron-manganese

carbide, cementite, which occurs on slow cooling, and not for the purpose of retaining an austenitic state. Broad plates of this cementite embrittle the mass by forming partings of low cohesion.

The commercial value of this higher manganese content steel seems to be due to its combination of high ductility with great effective hardness. Initially this steel appears rather soft, having a Brinell hardness of 125 on undeformed metal while this hardness increases very decidedly as a result of a small amount of deformation.

The hardening of manganese steel due to deforming, resembles in part the same course which leads to the increase of cohesion in general, including hardness, of all of the malleable metals undergoing deformation, such as wire drawing, and in part the martensitization of austenite. The retarded transformation from austenite through martensite to the alpha state due to cooling through the transformation range, is held back by the retarding action of manganese but is stimulated by any deformation to cause it to proceed as far as the martensitic state, thus causing hardening and embrittling. Martensitization by deformation thus stimulating arrested transformation is a common property of austenitic steels which have but a small excess of the retarding elements over the quantity needed for the retention of the austenitic state.

QUESTION NO. 29. Does the macrostructure of a piece of steel ever reveal imperfections which cannot be observed under the microscope or through chemical analysis?

ANSWER. The macrostructure, or the structure which is developed by polishing and deep etching with a suitable etching agent, a specimen of steel under examination very frequently reveals imperfections in the material which are not detected through the ordinary methods of chemical, physical and microscopic examinations. The fibrous structure is revealed by this type of etching as well as any dendritic conditions which may be of such a nature as to be detrimental. Full sized specimens, forgings, castings, etc., may be treated by this method permitting an examination of flow lines or excessively large dendrites. Dilute solutions of sulphuric acid, nitric acid, hydrochloric acid, ammonium copper sulphate, tincture of iodine, etc., are the usual reagents used. This method of testing is rapidly coming into extensive use.

QUESTION No. 30. How do the physical properties of a chrome molybdenum steel vary from the physical properties of a chrome vanadium steel after suitable heat treatments have been given to each?

QUESTION No. 31. What is the effect of oxidizing gases at low pressure on heated iron?

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Heat Treaters

By H. E. Gladhill

HEAT TREATING PROBLEMS

RELATION OF TIME FOR HEATING ROUND SECTIONS TO SURFACE PER POUND OF STEEL EXPOSED. By E. J. Janitzky, FORGING AND HEAT TREATING, Vol. 8, Page 179.

Using data presented by M. E. Leeds in a paper entitled "Some Neglected Phenomena in the Heat Treatment of Steel," an equation is developed giving the time required to bring steel to heat in terms of surface and lag for a given temperature.

Time = 5.3 (a constant) + Lag (a quantity depending on temp.)

Surface in sq. in. per pound of steel

MODERN METHODS OF MAKING LEAF SPRINGS. By E. F. Lake, IRON AGE, Vol. 109, Page 1269.

The plant of the American Auto Parts Co. is described. The forming (except for the eyes) and hardening operations are accomplished with a single heating of the steel. The heating operations both for hardening and tempering are carried out in oil fired furnaces of the intermittent type. After tempering the springs are assembled and tested.

METALLOGRAPHY AND HARDNESS THEORY

A DISCUSSION OF THE SLIP INTERFERENCE THEORY OF HARDENING. By P. D. Merica, CHEMICAL AND METALLURGICAL ENGINEERING, Vol. 26, Page 881.

Merica considers that the keying action alone of the dispersed particles is not sufficient to account for hardening, and that cohesive forces between the key particles and the matrix must be considered as playing an important part. Two additional points; the fact that maximum hardness does not involve minimum ductility and that extreme cold work causes softening, are brought up.

CRYSTAL GROWTH IN METALS. By G. R. Fonda, GENERAL ELECTRIC REVIEW, Vol. 25, Page 305.

Crystallization the effect of cold work on crystal structure, recrystallization, and grain growth are discussed in a general way. No new data is presented. A well selected bibliography is given.

ON DELAYED CRYSTALLIZATION IN CARBON STEELS: THE FORMATION OF PEARLITE, TROOSTITE AND MARTENSITE. By A. F. Hallimond, Presented at the May Meeting of the Iron and Steel Institute (London).

The analogy between the equilibrium relations of a ferrite, cementite and austenite, and two mutually insoluble solids, crystallizing from a liquid solution, is well established, but similar relations for martensite and troostite are not yet well recognized. Study of the principles underlying "delayed crystallization" offer possibilities. Investigations have developed that two regions, the metastable and the labile separated by the supersaturation curve are to be found below the stable equilibrium lines for many pairs of substances. A zone is also to be found in the metastable area in which the effect of inoculation (with an isomorphous substance) becomes apparent. On reaching the labile area, the substance in solution will separate as a shower of crystals. On this basis, martensite is interpreted as being a labile shower of a-ferrite and troostite as a labile shower of cementite.

METALLURGICAL EDUCATION AND RESEARCH

STEEL FOUNDRIES CO-OPERATE IN JOINT RESEARCH. By D. M. Avey, IRON TRADE REVIEW, Vol. 70, 1471.

The Electric Steel Co. (Chicago), The Fort Pitt Steel Castings Co.

(McKeesport, Pa.), The Lebanon Steel Foundry (Lebanon, Pa.), The Michigan Steel Casting Co. (Detroit), and the Sivyer Steel Castings Co. (Milwaukee) make up the group. The method of co-operation is outlined. Maj. R. A. Bull has been retained as advising expert. Problems investigated to date include abrasives, annealing, core practice, facing sand, furnace practice, and the effect of the presence of slag in castings.

STEELS

STEEL FOR FORGE WELDING. By F. N. Speller, BLAST FURNACE AND STEEL PLANT, Vol. 10, Page 259.

As a result of some 80 tests it was found that steel of 0.15-0.20 per cent carbon is best suited for forge welding. Suitable material, well-trained operators, and adequate control facilities are essential for the uniform production of such welds.

STEEL FOR CRANK SHAFTS: ITS HEAT TREATMENT. By H. C. Loudenbeck, FORGING AND HEAT TREATING, Vol. 8, Page 181.

Three classes of steel are used in crank shafts: (1) carbon steel, annealed or hardened, (2) carbon steel, case hardened, and (3) alloy steels, heat treated. In class 1, S.A.E. 1035-1045 is used, in class 2, S.A.E. 1020 is used, and in class 3 the most commonly used is nickel chrome steel such as S.A.E. 3135. Chrome molybdenum and chrome vanadium steels are also used. The heat treatment and physical properties for each class of steel are given.

BALL BEARING STEEL AND ITS HEAT TREATMENT. By C. T. Hewitt, FORGING AND HEAT TREATING, Vol. 8, Page 196.

Steel used for ball bearings and races is usually high carbon steel, containing 0.60 to 1.50 per cent chromium. The lower chromium steels are used for the balls. The annealing and hardening operations used are described in general terms.

THE USE OF MOLYBDENUM STEEL IN THE AUTOMOTIVE INDUSTRY. By J. D. Cutter, JOURNAL SOCIETY OF AUTOMOTIVE ENGINEERS, Vol. 10, Page 340.

The use of chrome-molybdenum steels are recommended for automobile frames, a considerable reduction in weight being made possible thru their use. Carbon molybdenum steels are recommended for pressed steel parts. Manufacturing costs are said to be reduced thru the use of molybdenum steels due (a) to their wide heat treating range and (b) their ease of machining. A discussion of the article is given.

TESTS ON FERROUS MATERIALS

RECENT RESEARCHES ON STATIC NOTCHED BAR TESTING. By H. A. Holz, CHEMICAL AND METALLURGICAL ENGINEERING, Vol. 26, Page 941.

Curves showing the results obtained by pulling notched test pieces (Izod type) in a static machine are presented. More valuable data can be gained thru the use of the static machine since one can follow the test step by step, a thing not possible with impact machines.

THE RESISTANCE TO TORSION AND BENDING OF STEELS BETWEEN ROOM TEMPERATURES AND VISIBLE RED. By M. J. Seigle, REVUE DE METALLURGIE, Vol. 19, Page 178.

A method is described for demonstrating in a striking way the influence of temperature on the properties of steel. If small single groves are filed in uniform rods to be tested in torsion and sections of these rods heated while being twisted, the grove will form a helix with turns closest together in that part of the rod which the temperature had rendered the most ductile. Similar tests may be carried out in tension, except that here a series of small nicks are spaced at even distances along the rod.

THE TESTING OF DROP FORGINGS. By Leslie Aitcheson, FORGING AND HEAT TREATING, Vol. 8, Page 188.

The tests which may be carried out advantageously on drop forgings are (a) chemical analysis, (b) physical tests, (c) microscopic examination, (d) macroscopic examination, (e) service tests, and (f) design tests. Tests a and b are recommended for the raw steel, tests b, d, e, and f for the drop forgings, and tests c, e, and f for forgings which fail in service.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J. represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

ALLEN, C. A., (M-5), 73 Sigourney St., Hartford, Conn.
BARKLING FUEL ENGINEERING CO., (S-5), 1743 N. Kenton, Ave., Chicago, Ill.
BARTON, C. R., (M-6), Standard Seamless Tube Co., Ambridge, Pa.
BELKNAP, R. E., (A-6), 1917 Peoples Gas Bldg., Chicago, Ill.
BOLLINGER, P. G., (M-5), 2013 4th Ave., Altoona, Pa.
BRANCH, T. H., (S-6), Pullman Car Works, Pullman, Ill.
BRANDT, P. L., (Jr-5), 505 6th St., Washington, D. C.
BURKHARDT, F. C., (M-4), The Crosby Company, Buffalo, N. Y.
CALKINS, C. H., (M-5), Bausch Machine Tool Co., Springfield, Mass.
CORNISH, F., (M-6), 3 Greenwood Avenue, Blue Island, Ill.
CROSBY, V. A., (M-6), 1252 Lincoln, West, South Bend, Ind.
DAY, J. R., (M-6), 15315 Turlington Ave., Harvey, Ill.
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FREY, A. A., (M-5), 1115 Wallace Ave., Wilkinsburg, Pa.
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GRANGER, L. D., (M-4), 69 Hammond St., Worcester, Mass.
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HASSLER, L. W., (Jr-6), 728 Fullerton Ave., Chicago, Ill.
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HERMAN, G. N., (A-6), 1140 W. Washington Blvd., Chicago, Ill.
HOMMERBERG, V. I., (M-6), Massachusetts Inst. of Tech., Cambridge, Mass.
HOOVER, Wm., (M-4), American Rolling Mill Co., Middletown, O.
KAISER, H. F., (Jr-6), Lewis Institute, Chicago, Ill.
KINGSBURY, S. S., (Jr-5), Bureau of Standards, Washington, D. C.
KOLF, P. (M-5), Independent Pneumatic Tool Co., Aurora, Ill.
LASCHUK, SEDOR, (Jr-6), 904 W. Milwaukee, Chicago, Ill.
LAWRENCE, F. L., (M-5), Frost Gear & Forge Co., Jackson, Mich.
LECKINGER, LEON, (M-5), High Speed Hammer Co., Inc., Rochester, N. Y.
LEONARD, S. C., Jr. (M-4), 5418 E. View Park, Chicago, Ill.
LINDHOLM, G. F., (M-6), 4711 N. Seeley Ave., Chicago, Ill.
LOUGHREY, D. R., (M-5), 5538 Black St., Pittsburgh, Pa.
MAYER, C. A., (S-5), American Bosch Magneto Corp., Springfield, Mass.
McARDELL, W., (Jr-6), 15 Argyle Rd., Brooklyn, N. Y.
McBRIDE, (M-6), Colorado Bldg., Washington, D. C.
MORRELL, C. P., 511 Bulkley Bldg., Cleveland, O.
MUTCHLER, W. H. (Jr-5), Bureau of Standards, Washington, D. C.
NUTH, A. C. (M-5), 12046 Stewart Ave., Chicago, Ill.
PENNINGTON, T. W., (M-6), 1201 Fayette St., N. S., Pittsburgh, Pa.
PERETTO, ROBT., (M-5), 9021 Wilson, Dearborn, Mich.
PITTS, C. M., (M-5), Althea Ave., Gardenville, Baltimore, Md.
REMSEN, C. A., (S-6), 612 Albee Bldg., Washington, D. C.
ROSENBERG, S. J., (Jr-5), Bureau of Standards, Washington, D. C.
ROSSER, H. M., (M-6), Bureau of Standards, Washington, D. C.
SCRIMGEOUR, Wm., (A-6), 410 Albee Bldg., Washington, D. C.
SODEN, C. P., (A-5), 217 Broadway, New York City.
SMITH, W. J., (Jr-6) 1963 Leland Ave., Chicago, Ill.
STACKHOUSE, W., (M-5), 6631 Marsden St., Tacony, Philadelphia, Pa.
STANDFUSS, E., (M-6), 2933 Chestnut St., Milwaukee, Wis.
SUZNICK, GEO., (M-4), 354 Ogden Ave., Ardmore, Wilkinsburg, Pa.
SZWAIKART, T. G., (Jr-6), 2718 Francisco Ave., Chicago, Ill.
TALLMAN, V. M. F., (M-1), 2-1 Devonshire St., Boston, Mass.
TAYLOR, T. D., (M-6), 1416 Otto Blvd., Chicago Heights, Ill.
THOMPSON, W. D. (M-5), Indiana Natural Gas & Oil Co., East Chicago, Ind.
TOMMET, A. J., (M-6), 806 N. Chicago Ave., S. Milwaukee, Wis.
TUCKER, W. A., (Jr-5), 1523 22nd St., N. W., Washington, D. C.

UNIVERSAL STEEL CO., (S-6), Bridgeville, Pa.
WHIPPLE, H. S., (M-6), Rockford Gas Light & Coke Co., Rockford, Ill.
WRIGHT, C. O., (M-5), Indiana Natural Gas & Oil Co., East Chicago, Ind.

MAIL RETURNED

FOSTER, W. H., 1321 Oliver St., Indianapolis, Ind.
JONES, J. H., 83 Main St., Bristol, Conn.
STEPAN, Roessler & Hasslacher Chemical Co., Chicago, Ill.

CHANGES OF ADDRESS

BARR, H. L., (M-11)—from Follansbee Bros., Co., Follansbee, W. Va., to Trumbull Steel Co., Warren, O.
BUELL, Wm. C., (A-5)—from Geo. J. Hagan Co. to Buell-Scheib-Muller, Inc., Columbia Bank Bldg., Pittsburgh, Pa.
EDELIN, J. W., (M-5)—from 407 Evans Bldg., to 311 4th St., Washington, D. C.
EDINGER, J. J.—from 300 Hudson St., to 102 Hartford Rd., E. Syracuse, N. Y.
FOSS, F. F.—from Russian Embassy, to Care Mr. David White, Room 4241 Interior Bldg., Washington, D. C.
HAWKINS, E. R., (M-4)—from 724 Delaware St., to 391 Adams St., Gary, Ind.
HOYT, H. S., (A-4)—from 745 Washington St., New York City, to A. Milne & Co., 17 N. May St., Chicago, Ill.
JOHNSON, P. A., (Jr-5)—from 4235 N. Springfield Ave., to 4933 N. Tripp Ave., Chicago, Ill.
JOHNSON, W. G., (M-3)—from 1811 Wyoming Ave., Washington, D. C., to Doehler Die Casting Co., Brooklyn, N. Y.
KIEFER, H. G., (M-2)—from 1030 Beaconsfield Ave., to 1300 Seward Ave., Detroit, Mich.
MARSHALL, G. D.—from 1444 E. 116th St., to 2484 Lee Road, Cleveland, O.
POLHEMUS, G. J.—from 1238 Washington Blvd., Chicago, to Care Barbee Steel & Iron Co., E. Water at Huron St., Milwaukee, Wis.
PUTNAM, W. S.—from Universtiy of Ill., Urbana, Ill., to New Salem, Mass.
RHODES, P. S.—from 2721 Catherine St., to 4832 Vinewood, Detroit, Mich.
RUBY, W. J., (M-2)—from 2174 E. Warne Ave., to 2019 E. John Ave., St. Louis, Mo.
STERLING, J. D., (A-4)—from Hoskins Mfg. Co., 410 Sloan Bldg., to 947 Leader-News Bldg., Cleveland, O.

(*Continued from Page* 919)

tain whether any nonmagnetic iron could be trapped by rapid quenching or otherwise.

On the other hand the tests for coercive force were not at all exact, as the same coils and galvanometer were used as for the hardest steels.

The method for measuring coercive force is, however, quite applicable to iron, merely an adjustment for sensitiveness being required. As a matter of fact, before this paper was written, I had already carried out quite an extensive investigation on the effect of heat treatment of iron, measuring the coercive force only by the method described in the paper. This was not added to the paper, as my desire was to do no more than to present a general survey of my subject.

News of the Chapters

SCHEDULE OF REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Boston—Second Friday, Franklin Union, Corner Berkley and Appleton Sts., Meeting 8:00 P. M.

Charleston—First Tuesday, Kanawah Hotel, 8 p. m.

Chicago—Second Thursday, City Club, dinner 6:30 p. m., meeting 8 p. m.

Hartford—Thursday nearest 10th of month, Jewell Hall, Y. M. C. A., 7:45 p. m.

New York—Third Wednesday, Merchants Association of New York, Woolworth Building.

Philadelphia—Last Friday, Engineers Club.

Pittsburgh—First Tuesday, Chatham Hotel, dinner 6:30 p. m., meeting 8 p. m.

Rockford—Second Monday, Nelson Hotel.

Rochester—Second Wednesday.

Schenectady—Third Tuesday, Civil Engineering, Bldg., Union College.

Tri City—First Thursday following first Monday.

Washington—Second Friday.

STANDING OF THE CHAPTERS

In the June issue of the TRANSACTIONS was published the standing of the chapters of May 1st. The list below shows the standing of the chapters on June 1st.

1. Chicago
2. Detroit
3. Pittsburgh
4. Philadelphia
5. Cleveland
6. New York
7. Hartford
8. MILWAUKEE
9. **Boston*
10 **Lehigh Valley*
11. *Indianapolis*
12. *Syracuse*
13. Worcester
14. ROCKFORD
15. *Cincinnati*
16. **North West*
17. *SPRINGFIELD
18. *Tri City*
19. Providence
20. WASHINGTON
21. **St. Louis*
22. *New Haven
23. BUFFALO
24. *Schenectady*
25. Toronto
26. South Bend
27. Rochester
28. Bridgeport

*=Tied

The following explanations will be of assistance. The chapters shown in capitals have advanced their position from that occupied on May 1st. Those shown in italics are not occupying as high a position as in the previous report. Those printed in regular type (i.e. Chicago) are occupying the same position as in the previous report.

May was the best month for increase of membership the Society has had during the past year. One hundred and thirty-five new members were reported with dues paid, while about 40 applications were received not accom-

panied by dues and who did not remit before the first of June and consequently are not included in this report.

We all realize that business conditions are opening up and in a number of cities have opened up and we believe that you will agree that 'the time to strike is when the iron is hot,' and it is desirable for the chapters to continue their membership activities during the summer months. It should be an easy matter to continue the wonderful progress made in May, because two very important reasons: (1) that of receiving the TRANSACTIONS containing the Convention papers as well as (2) that a membership starting now will give the new member the advantage of all chapter meetings during the coming year, can be offered now and should make the securing of new members an easy proposition.

The largest increase of any chapter was shown by Chicago where 32 new members were added during the month.

Milwaukee is to be congratulated on changing its position from 12th in the last report to 8th on this report passing Indianapolis, Boston, Lehigh Valley and Syracuse.

Washington also made a very commendable record during the month having broken the tie in which they were involved during the last two reports and advanced their position from 23rd to 20th passing in the interim St. Louis, Schenectady and New Haven.

One of the pleasant observations to be made is that there is constantly being received at headquarters a large number of applications forwarded by individuals who are not members of Membership Committees but who in the course of their travels bring the Society to the attention of interested individuals.

All members of the Society should bear in mind that the railroads have granted fare and one-half for the round trip to the Detroit Convention but these certificates entitling the low fare are issued to members. So if you are acquainted with anyone who is going to the convention he will be able to more than save his year's dues by the reduction he will obtain by becoming a member of the Society and getting reduced rates to Detroit. And then again he will almost save his year's dues by the special privileges and advantages that will be offered to members at Detroit for which other individuals will have to pay.

BOSTON CHAPTER

At the annual meeting of the Boston Chapter which was held May 26th at the Boston City club, the election of officers for the ensuing year took place. Those members elected to office are as follows: Chairman, Z. L. Sault, New England Annealing & Tool Company; vice chairman, H. W. Porter, H. K. Porter Company; secretary-treasurer, W. J. Kunkel, Blake & Knowles Co.; executive committee, W. W. Cummings, Boston Consolidated Gas Company and E. E. Roberts, New England Metallurgical Corporation.

It was at this meeting that Mr. J. C. Spence of the Norton Company presented his very interesting paper entitled "Grinding Practice."

CHICAGO

At a recent meeting of the Chicago Chapter, the following members were elected as officers for the next year:

Chairman, H. F. Wood, Wyman Gordon Company; vice chairman, F. G.

Wheeler, 1953 Hastings street; secretary-treasurer, H. Blumberg, Illinois Steel Company; executive committee, A. G. Henry 3609 Lake Park avenue, E. J. Janitzky, Illinois Steel Company, M. E. Williams, 504 Oakwood boulevard, George Charlton, 2503 South Wood street, H. T. Moore, 760 Polk street.

The first annual outing of the Chicago Chapter was held on the afternoon of June 10 at the Hartman House, Wheeling, Ill., which is about twenty-two miles from the loop on Milwaukee avenue. A large number of tickets had been sold and about 250 members and guests were taken to the Hartman House by automobile. These automobiles were furnished largely by the members of the chapter.

The announcement of this outing stated that An Honest-to-God, Old Fashioned Home Cooked Chicken Dinner, and all that goes with it would be served at the Hartman House, and the announcement had not exaggerated it in any way.

After everybody had filled up on good things there were all sorts of entertainment, baseball, tennis and boating were available for everyone.

After a rousing good time indulging in and enjoying all of the out door sports available, the party returned to Chicago about 6:30. It was unanimously voted by all those who attended that they had had one grand time.

A detailed report of this outing will be given later.

CINCINNATI CHAPTER

The Cincinnati Chapter held it annual meeting in the rooms of the Ohio Mechanics Institute on June 8th. The speakers for this meeting were John C. Spence and C. H. Norton, of the Norton Company. Both men presented a paper entitled "Grinding of Steel." The paper proved to be exceedingly interesting and instructive and brought forth considerable new ideas on the grinding of steel and developed a large amount of discussion after its presentation. About 75 members and guests were present at this meeting.

Following the paper and the short order of business, the election of officers for the ensuing year was held. The members elected are as follows:

Chairman, Dr. J. C. Hartzell, Blue Ash, Ohio; vice-chairman, A. L. Myers, R. W. LeBlond Machine & Tool Company; secretary-treasurer, Fred L. Martin, 705 Elm Street; executive committee, C. H. Waldo, Ohio Knife Company; Edward Gardner, Modern Tool & Mfg. Company; W. J. Wersel, Allis Chalmers Mfg. Company; W. T. Cowell, Lodge & Shipley; E. W. Detraz, University of Cincinnati.

CLEVELAND CHAPTER

The Cleveland Chapter held its last meeting for the season on Thursday evening, June 1st in the ball room of the Hotel Winton. Following the regular order of business, Prof. H. M. Boylston presented a paper entitled "Migration of Carbon in Iron." This paper was the result of considerable research work at the Case School of Applied Science. Some very interesting facts regarding the migration of carbon in iron and steel were developed, and it is hoped that in the near future this paper may be printed in the TRANSACTIONS.

Professor Boylston's paper brought forth considerable discussion on the theory of the migration of carbon. Following this paper the final report of the secretary was read and approved. Reports from the various standing committees were also read. The report of the Nominating committee had

been presented at the previous meeting. It was moved that the recommendation of the Nominating committee be accepted unanimously. This motion was approved and carried. The officers for the ensuing year are:

Chairman, Prof. H. M. Bolyston, Case School of Applied Science; vice chairman, R. T. Bayless, 4600 Prospect avenue; secretary-treasurer, D. M. Gurney, Warner & Swasey Company; executive committee, C. G. Shontz, Perfection Spring Company, Wm. H. Brainard, Carnegie Steel Company, M. L. Burchfield, 1380 West Seventy-third street, V. M. Wellman, 1224 Oregon avenue, W. S. Bidle, W. S. Bidle Company, R. S. Archer, Aluminum Castings Company.

Following this order of business, the chapter was entertained by some professional performers who put on a very interesting and pleasing entertainment in the form of dancing and singing.

It was announced that the next meeting would be held in September.

DETROIT CHAPTER

The result of the annual election of officers of the Detroit Chapter was announced at the May 27th meeting of the chapter. They are as follows:

Chairman, J. L. McCloud, Ford Motor Company; vice chairman, Walter E. Jominy, Studebaker Corporation; secretary-treasurer, W. G. Calkins, Detroit Twist Drill Company; executive committee, J. M. Watson, Hupp Motor Car Company; H. M. Bray, Cadillac Motor Car Company; Robt. Atkinson, Maxwell Motor Company; F. E. McCleary, Dodge Bros.; R. E. Surtees, Studebaker Corporation.

On June 1, the Executive Committee held a meeting primarily for the appointment of the Papers & Meetings, Membership and Research Committees for the year 1922-23.

Bob Atkinson will have charge of the Papers & Meetings so we are looking forward to some very interesting meetings. W. E. Blythe will undertake the job of doubling our membership next year, and Walter Jominy will head the Research Committee.

We are looking for big things from the Detroit Chapter and from the excellent manner in which the convention arrangements are being handled. Detroit will have a wonderfully successful year as a result of their untiring activities.

HARTFORD CHAPTER

The May meeting of the Hartford Chapter was held Thursday evening, May 11th, in Jewell Hall, Y. M. C. A. Mr. James J. Curran, Metallurgist for the Henry Souther Engineering Company, delivered an excellent illustrated address on "The Inspection and Heat Treatment of Steel." Particular stress was laid on the value of deep etching discs cut from bar stock for revealing inclusions; pipes, seams, etc. The slides of the etched disc and microphotographs of the same were excellently prepared and very instructive.

The local Standards committee consisting of Messrs. Lanning, Green and Olsen submitted their report on the chemical specifications prepared by the National Standards committee. The following resolution on this subject of Chemical Specifications was voted on at this meeting and adopted by a unanimous vote. "Resolved that it is the concensus of opinion of the Hartford Chapter that efforts should be made to promulgate heat treatment specifications rather than attempt to promote new steel specificaions."

Mr. Arvid Anderson, chairman of the nominating committee, presented the names of the members nominated for office for the coming year and

the following men were elected: Chairman, A. H. d'Arcambal, Pratt & Whitney Co.; vice chairman, J. J. McIntyre, McIntyre Machine Co.; Secretary-treasurer, J. J. Curran, Souther Engineering Co.; Executive Committee, M. E. Gere, New Departure Mfg. Co., Bristol; H. I. Moore, Firth Sterling Steel Co.; Cyrus Blackman, Colts Patent Fire Arms Co., Elmwood; G. P. Moore, Wallace Barnes Co., Bristol; Theodore Jacobson, S.K.F. Ball Bearing Co.,Hartford; E. S. Lewis, Stanley Works, New Britain; R. K. Newman, Frasse Steel Works; L. A. Lanning, New Departure Mfg. Co.

Mr. David O'Brien of the Pratt & Whitney Co., came out with first honors in the heat treating contest held in March. Mr. O'Brien obtained 400 points, his nearest competitor being Mr. Anderson of the New Departure Mfg. Co. with 185 points. Mr. O'Brien was presented with a large box of cigars as a reward for his excellent work in this contest.

The annual banquet was held June 9 at 7 P.M in the ball room of the Bond Hotel. Mr. Charles Carpenter, President of the E. F. Houghton Company and Editor of "The Houghton Line" was the principal speaker of the evening. Mr. Carpenter is well known throughout the United States for his versatile editorials and his style of attack was indeed very entertaining. It was a privilege of the chapter to be able to have him with them.

Mr. Hathaway's Entertainment Committee promised special interesting features for this meeting and they surely did come across in good shape.

INDIANAPOLIS CHAPTER

The regular monthly meeting of the Indianapolis Chapter was held in the Directors' Room of the Chamber of Commerce, Monday, May 8. The meeting was opened at 8 o'clock by Chairman W. R. Chapin. The election of officers was held and the following men were elected for the ensuing year:

Chairman, P. O. Deeds of the Indianapolis Manufacturing Company, and secretary-treasurer, John Q. Holmes of Nordyke & Marmon Company.

After a short business discussion, Mr. Clark of the Norton Company was introduced and presented a very interesting talk on "Grinding and the Manufacture of Abrasives." His talk was illustrated with lantern slides. Following the paper an informal and interesting discussion resulted. Mr. Clark brought with him many interesting samples of ground work, illustrating results of proper and improper methods of grinding.

About 60 members and guests attended this meeting.

The regular monthly meeting for June was held in the rooms of the Indianapolis Chamber of Commerce on June 12. The meeting was opened by Chairman Paul O. Deeds and a short business session was held during which the discussion of plans for the ensuing year was brought out. In connection with this session a motion was carried that the chairman appoint a committee to draw up a simple glossary of technical and metallurgical terms that would enable the man at the fire to understand to better advantage the papers in the TRANSACTIONS and discussions at the meetings of the local chapter. This was done in an effort to interest the workmen in the Society with the hope of increasing the membership by obtaining such men as members.

Delegates to the Detroit Convention were appointed and are as follows:

A. L. Cramp and H. B. Northrup.

Following the business session, the meeting was turned over to Mr. H. E. Haywood of the Link Belt Company who explained the "Making of a Link Belt." This talk was illustrated with stereopticon slides and with photo

micrographic specimens which were examined through a metallographic apparatus loaned by Mr. Haywood. Following this paper a round table discussion took place. The meeting adjourned at 10:30 o'clock until September.

SPRINGFIELD

The Springfield chapter held its May meeting in the rooms of the Chamber of Commerce on the 26th. Mr. H. B. Byers, president of the New England Metallurgical Corporation, of Boston, was the speaker of the evening, and presented his paper entitled "Practical Points in Heat Treating." Mr. Byers had been long connected with the Watertown Arsenal and is at present connected with the New England Metallurgical Corporation where all kinds of commercial heat treating is handled, qualifying him in a very excellent manner to discuss the subject of his paper. It was presented in a very interesting manner and aroused considerable interesting discussion.

The last meeting of the Springfield Chapter was held on Friday evening, June 16th in the Chamber of Commerce Building. In accordance with the custom for the past two years, the final meeting of the season was a get-together meeting.

A very satisfactory report covering the year's work was presented by the secretary at this meeting, after which followed the election of officers. The new officers are as follows:

Chairman, A. E. Sanford, metallurgist, Hendee Manufacturing Company; secretary- treasurer, E. L. Woods, Springfield Gas Light Company.

A paper prepared by Mr. V. Malcomb, metallurgist of the Chapman Valve Manufacturing Company and entitled "Acid Electric Steel," was read by the newly elected chairman, on account of the author's absence.

Mr. E. L. Wood, metallurgist at the Springfield arsenal presented a short talk on "Methods of Determining the Elastic Limit of Steel in Tension and Its Use in Engineering Designs. The discussion following both talks was most interesting and instructive.

MILWAUKEE CHAPTER

On May 23, the Milwaukee Chapter of the American Society for Steel Treating held a joint meeting with the Milwaukee Chemical society in the banquet hall of the Republican house.

Mr. Zay Jeffries, Cleveland, of the Aluminum Company of America, was the speaker of the evening. His subject was "The Hardness of Metals," and his lecture was illustrated with lantern slides. By his talk and through the medium of his slides, he represented the various crystalline structure of metals. He emphasized treatment "as one of the most important features in the metal industry," and explained why certain treatments render the metal either hard, tough or elastic.

Nearly 100 of the manufacturing interests of Milwaukee were represented at the meeting.

NEW HAVEN

The final meeting of the New Haven Chapter was held Wednesday evening May 31st in the Cafe Mellone. A. H. d'Arcambal, chief metallurgist of the Pratt & Whitney Company, presented a paper entitled "High Speed Steel." This paper was illustrated with lantern slides and heat treated speci-

mens were passed around. It was announced that any who had been having trouble with high speed steel treating should come prepared with questions for discussion. This proved to be highly satisfactory inasmuch as a good lively discussion followed Mr. d'Arcambal's paper which brought out some valuable information pertaining to the heat treatment of high speed steels.

NEW YORK CHAPTER

The New York chapter held its regular June meeting in the assembly room of the Merchants Association of New York in the Woolworth building, June 21st.

Three very excellent papers were presented to the members assembled. They were as follows:

"Tool Room Troubles" by A. H. Kingsbury of the Crucible Steel Company of America, Pittsburgh.

"Carbonizing Practices" by John F. Wyzalek, Hyatt Roller Bearing Co., Harrison, N. J., and "Salt Baths" by Sam Tom, Dohler Die Casting Co., Brooklyn, N. Y.

These papers aroused a large amount of discussion and the meeting proved to be one of the best of the season.

NORTH WEST CHAPTER

The annual meeting of the North West Chapter was held Friday evening May 26, and the following officers and Executive Committee were duly elected to serve for the ensuing year:

H. Kenneth Briggs, chairman, Minneapolis Electric Steel Castings Co.; W. E. Johnston, vice-chairman, Mahr Manufacturing Company; Alexis Caswell, secretary-treasurer, 200 Builders Exchange Building; executive committee, Ralph Dowdell, University of Minnesota; Oscar E. Harder, University of Minnesota; J. C. Irwin, Thexton Manufacturing Company; Chester S. Moody, Minneapolis Steel & Machinery Company; N. H. Plouff, 17 East Lake Street.

The speaker of the evening was Mr. O. T. Muehlemeyer of Barber-Colman Company, Rockford, Illinois, whose subject was "Tool Hardening." Mr. Muehlemeyer's paper aroused much interest, and it is hoped that his paper will be published in the near future. The paper was written in a very interesting manner and aroused considerable discussion and was a very capable presentation.

The tenth and last lecture in the Educational Course was held Monday, June 12 at 8 o'clock at the Manufacturers' Club. Mr. Francis B. Foley of the U. S. Bureau of Mines, presented the lecture entitled "Alloy Steels."

These meetings have proved exceedingly interesting and beneficial to all who have availed themselves of this opportunity of attending and hearing the various men who presented lectures, discussing the subjects in which they are experts.

PHILADELPHIA CHAPTER

The last meeting of the Philadelphia Chapter was held Thursday evening, June 1st, in the Engineers' Club Auditorium. Mr. Jerome Strauss, metallurgist and chief chemist, Washington Navy Yard presented an illustrated paper on "Characteristics of Some Manganese Steels." Mr. Strauss is a

recognized authority on the subject of manganese steels and his paper gave

ARTHUR W. F. GREEN
Re-elected Chairman of the Philadelphia Chapter

some very important information relative to them. A very interesting and instructive discussion followed this paper. Following the paper of the evening

ARTHUR L. COLLINS
Re-elected Secretary-Treasurer of the Philadelphia Chapter

the following members were elected as officers for the ensuing year:

Chairman, A. W. F. Green, John Illingworth Steel Company; vice chair-

man, E. H. Barker,, A. H. Wirz, Inc.; secretary-treasurer, A. L. Collins, 5616 Crowson street; executive committee, J. J. Crowe, Philadelphia Navy Yard, W. M. Mitchel, 112 North Thirty-fourth street, D. K. Bullens, 909 West Tioga street, J. W. Barnett, 1228 Callowhill street, L. A. Cummings, Standard Steel & Bearings, Inc.

ST. LOUIS CHAPTER

The last meeting for the present year was held on June 8th at the Engineers' club. The speaker of the evening was Mr. W. W. Cox, Commercial Chemist, who presented a very capable paper entitled "Utilization of Pig Iron." Mr. Cox is a well known metallurgist in St. Louis and what he

C. B. SWANDER
Elected Chairman of the St. Louis Chapter

had to say about pig iron was very instructive. His paper brought forth considerable interesting discussion on foundry practice.

Following the paper of the evening the following members were elected as officers for the ensuing year:

Chairman, C. B. Swander, Wagner Electric Mfg. Company; vice chairman, Carl Krutzsch, St. Louis Frog & Switch Company; secretary-treasurer, G. S. Rogers, E. F. Houghton & Company; executive committee, Lor. Clarke, Leschen Wire Rope Company, F. Hamman, Mound Tool Company, F. A. Lawler, Crucible Steel Company, W. J. Ruby, Landis Machine Company, Francis White National Enameling & Stamping Company.

SCHENECTADY CHAPTER

The last meeting of the Schenectady Chapter was held May 25th in the Civil Engineering Building of Union College. The paper for this meeting was presented by Stanley P. Rockwell, consulting metallurgist of Hartford, Conn., entitled "Carburizing." Although carburizing is one of the older processes of treating steel, there are still many things to be learned

regarding it and Mr. Rockwell's paper described numerous new developments of the process. A lively discussion was held following this paper after which the election of officers took place.

LEHIGH VALLEY

The Lehigh Valley Chapter announces the following members that have been duly elected to office for the ensuing year:

Chairman, John E. Halbing, Ingersoll-Rand Company, Phillipsburg, N. J.; secretary-treasurer, Albert P. Spooner, Bethlehem Steel Company; executive committee, M. Laury, 256 Goepp street, Bethlehem, Pa., W. R. Shimer Bethlehem Steel Company, Bethlehem; G. C. Lilly, 707 West Market street, Bethlehem, F. P. Martin, 728 Reeder street, Easton, Pa., A. S. Hummel, 122 North Third street, Easton, Pa., R. Christ, 2023 West Broad street, Bethlehem, H. S. Brainerd, 121 Wayne avenue, Easton, E. B. Shimer, 94 Pennsylvania avenue, Easton, B. H. DeLong Carpenter Steel Company, Reading, Pa.

TRI CITY

The last meeting of the season of the Tri City Chapter was held June 1st in the rooms of the Davenport Chamber of Commerce. The meeting was opened by Chairman A. H. Putnam at which time the annual report of the secretary-treasurer was read and approved. The following members were unanimously elected to office for the ensuing year:

Chairman, J. F. Lardner, Jr., John Deere Plow Works, Moline, Ill.; vice chairman, L. S. Rasmusen, Linograph Company, Davenport, Iowa; secretary-treasurer Human Bornstein, 636 Tenth street, Moline, Ill. The executive committee consists of the newly elected officers and A. H. Putnam and C. H. Lage.

A motion was made and carried, in which the chapter extended a vote of thanks indicating their appreciation for the services of the out-going officers during the past year. After this meeting, A. H. Putnam, consulting metallurgist, presented a paper entitled "The Use of Various Tool Steels." This paper proved very instructive and aroused a great deal of interesting discussion. Mr. Putnam was given a vote of thanks after which the meeting adjourned.

WASHINGTON CHAPTER

At the May meeting of the Washington Chapter the following members were elected to office to serve for the ensuing year. They are:

H. J. French, chairman, Bureau of Standards; P. E. McKinney, vice-chairman, U. S. Naval Gun Factory; Jerome Strauss, secretary-treasurer, U. S. Navy Yard; executive committee, J. S. Vanick, 2034 F Street, N.W.; J. W. Talley, 1926 North New Hampshire Avenue, I. N. Beatty, 407 Evans Building, C. B. Scrimgeour, 410 Albee Building.

Commercial Items of Interest

MR. A. C. WEBSTER, a graduate of the School of Mechanical Engineering at Purdue University and whose reputation is international as a result of his efforts in the development of cold forging and cold heading of alloy and high carbon steel, has recently tendered his resignation as head of the cold heading plant of the Ford Motor Company at Highland Park, Michigan. The cold heading plant of the Ford Motor Company where millions of pieces are turned out daily is conspicuous among Ford units as a direct result of the efforts of Mr. Webster who has been superintendent of the plant for the last five years. Under his guidance the development of highly specialized tools and machines involving many labor saving devices is accredited to the cold heading department.

Mr. Webster is a member of the American Society for Steel Treating and is internationally known as a steel expert. He is now a practicing consulting mechanical and industrial engineer specializing in cold forging and cold heading. His office is at 903 West Euclid avenue, Detroit, Michigan.

Mr. F. J. Griffiths, General Manager of the Central Steel Company, Massillon, Ohio, has announced that two production records were broken during the month of May at the plants operated by his company. At the steel plant, more steel was produced during May than in any previous month in the plant's history, while the National Pressed Steel plant also had a greater production in May than in any previous month.

A recent scientific paper of the Bureau of Standards No. 433 by Wilmer Souder and Peter Hidnert deals with the thermal expansion of a few steels. Data on thermal expansion of 28 samples of iron and steel are included, one sample of vacuum electrolytic and one of gray cast iron are also included. A specimen of hardened steel has been tested to show the dimensional change incident to heat treatment or drawing. Twenty-two curves and a two-page table are used to summarize the results.

A brief review of some of the previous work on expansion is included.

The E. J. Codd Company, 700 South Caroline street, Baltimore, Maryland, have recently distributed several bulletins describing in detail the use of chain furnace doors. These bulletins are illustrated showing the actual application of numerous installations of chain doors of heating furnaces.

Wilson-Maeulen Company, Inc., New York City, has published a 20-page illustrated booklet in which pyrometers, pyrometer recorders, etc., are described and illustrated. A multirecord, multicolor pyrometer recorder is included in the equipment described. This operates with base metal or rare metal thermocouples in a thermoelectric pyrometer service. It also operates

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EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice.

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITION WANTED

METALLURGIST or SUPT. HEAT TREATING—Technical graduate University of Illinois. Experience in heat treating and annealing forgings and castings all sizes up to 50 tons; production study and estimating; metallurgy, metallography, chemical analysis; physical testing and final inspection; installation and maintenance various makes pyrometers; research and investigation; three years superintendent heat treating. Age 30. Address 4-12.

METALLURGIST—or Supt. of Heat Treating with 12 years experience, 10 of which have been as executive in charge of laboratories and supervisor of metallurgical operations in Steel Works and industrial plants. Broad experience in chemical, physical and metallographical testing and the heat treatment of automobile and other alloy steels. Location desired East of Pittsburg, age 30, married. Address 4-7

SUPERVISOR HEAT TREATING. Chemical, Metallurgical Metallographical Laboratory large Motor Truck Company. 12 years experience. Formerly with U. S. Steel Corporation, U. S. Government Engineer of Tests & Metallurgist, also foundry experience in malleable, gray iron, steel, semi-steel. Age 35. American. Married. Eastern location preferred. Wages desired $200.00 per month. Answer 3-25.

ENGINEERING or PRODUCTION WORK—Technical Graduate. 2 years heat treatment of armor plate, guns, etc. 2 years charge heat treatment auto parts. 2 years charge commercial heat treating shop. At present employed as equipment sales agent. Desire to make change to engineering or production work. Salary desired $200-$250. per month. Address 5-25.

SALESMAN—Graduate University of Pittsburgh. 3 years chemist. 3½ years chemist and metallurgist. 3½ metallurgist and chief inspector. Experience in all departments of mill work, rods, wire, plates, spikes, etc. Familiar with nearly all classes of steels including alloys. Location preferred Pittsburgh. Address 5-30.

METALLURGIST—10 years experience in carburizing and heat treatment of carbon, alloy and tool steels. Extensive experience in physical testing, metallography, pyrometry and metallurgical research. Also experienced in handling large forces of men. Have had as many as 600 men under my supervision. Eastern location preferred. Salary desired $4500. per year. Address 5-35.

SUPERVISOR HEAT TREATING—Or assistant. Ten years experience as chemist on iron and steel. One year practical experience on metallurgical inspection directly connected with heat treatment. Have made a study of the subject. No preference as to location. Wages $40.00 per week desired. Answer 5-50.

FURNACE DESIGNER and BUILDER—Steel treating furnaces or to take charge of furnace construction and repairs in steel treating department of large manufacturing plant. A number of years experience designing, building and operating furnaces of all types for all classes of work including mechanical and automatic furnaces for heat-treating, carbonizing, and annealing. Willing to make part of compensation dependent upon ability to improve quality of work and reduce costs. Location immaterial. Address 5-5.

ASSISTANT METALLURGIST—4½ years experience in U. S. Armories, 4 years laboratories brass rolling mill and shell factory. Experience included installation and maintenance pyrometers, research work, micro examinations and microphotography, critical temperature measurements and carburizing and heat treatment of small parts. Willing to consider any position in metallurgical department, annealing or heat treating department providing there is opportunity for advancement. Wages desired $150.00 per month. Location preferred Rhode Island, Massachusetts, or Connecticut. Address 5-15.

METALLURGIST AND ENGINEER—Experience in purchasing, production, layout, forge shop, heat treating, laboratory and research work. Capable of taking entire charge of malleable, gray iron, semi steel or steel foundry. Desires employment with progressive firm. Address 5-41.

CHEMIST—Metallurgist, metallographist, physical tester or heat treater. 12 years experience. Former Government metallurgist. Now an executive with large motor truck company. Also malleable and semi-steel foundry experience. Can organize and manage men. No location preferred. Address 5-10.

SALES ENGINEER—Thorough metallurgical training and experienced salesman. At present employed but desires change. Wide acquaintance New York, New England and Canada. Basic knowledge foreign markets and can produce. Age 28. Married. Address 4-5.

METALLURGIST OR CHEMIST—Graduate of Ohio State. Extensive experience covering heat treatment, case hardening, pyrometry, chemical analysis, metallography, and investigation of tool troubles. Best of recommendations. No preference as to location. Address: 4-50.

Was connected with United States Naval Ordnance Plant having charge of metallography and heat treatment the past two years, has had practical electric melting experience. Best of recommendations. No restrictions of location. Address 4-35.

HEAT TREATING DEPARTMENT—Technical graduate. Hardening room automobile firm. Experienced on aluminum castings. Die Superintendent and metallurgist for steel tool company. Salary $150.00. Cleveland location preferred. Address 4-10.

EMPLOYMENT SERVICE BUREAU

POSITION WANTED

SUPERINTENDENT OF HEAT TREATING—7 years experience heat treating of carbon, highspeed and other alloy steels. Experience in metallographic testing Understands pyrometry. Techincal education. Best of references. Location desired, Chicago or near vicinity. Address 6-15.

SERVICE MAN—for steel company. Experience in heat treatment of carbon, high speed and alloy steels, also metallographic testing and pyrometry. Technical education. Best references. Address 6-20.

SALES REPRESENTATIVE—At present holding responsible executive position. Desires to become representative of one or more manufacturing lines in excellent territory. Companies especially desiring representative for materials used in heat treating will find it to their advantage to correspond with No. 7-5.

CHEMIST AND METALLURGIST—thoroughly experienced in analysis of ferrous and nonferrous metals. Specialist in alloy steel analysis. Capable of taking charge of chemical and physical laboratory. Best of references. Age 30. Married. Salary commensurate with ability. Answer 7-20.

CHEMICAL AND METALLURGICAL ENGINEER with business education and 3 years practical consulting experience desires a position in laboratory or production departments. Address 7-30.

POSITIONS OPEN

WANTED—Young college graduate with one or two years practical experience in physical metallurgy to carry out physical tests and micro examination with a government bureau. Entrance salary $1800 per annum. Position offers excellent opportunity to become familiar with certain phases of physical metallurgy of great practical value. Address 4-32.

WANTED—Practical Superintendent for tool steel wire and shape drawing department. Reply box 6-5. care American Society for Steel Treating.

WANTED—In tool and alloy steel research department 1921-1922 technical graduate who has specialized in iron and steel metallurgy. Duties include running experimental melting furnaces, oil and electric; heating furnaces; and wide range of general work. Position offers good opportunity for future. Address 7-15.

FOR SALE

FOR SALE—Commercial Heat Treating Plant. Established business in good field. Excellent opportunity for young metallurgist to get into business for himself. Answer 7-10.

Leeds & Northrup, Hump Method, Electric Furnace for sale. Used very little. Address 6-1.

FOR SALE—A ten-ton Gronwell-Dixon electric furnace with all accessories. This furnace is in excellent condition and is available at a very attractive figure. Address 7-25.

(*Continued from Page 939*)

as a low temperature recorder or electrical resistance thermometer in connection with resistance thermometer bulbs. Full details are given in the booklet, which also includes descriptions of parts, accessories, etc.

Alloys and alloy steel will be studied intensively by about sixty students in the department of mechanical engineering of the college of engineering of the University of Wisconsin. This subject is included in a new course in metallography. An increasing demand from factories and shops for men who know the heat-treatment of metals and alloys as well as understanding the properties of alloys has brought about the introduction of this new study.

The Burgess-Norton Manufacturing Company regrets to announce the suddent death, on Saturday, May 13, 1922 of their President Mr. Frank A. Burgess.

The Ithaca, N. Y., office of the Bureau of Mines is continuing the study of special series of molybdenum and cerium steels. Endurance tests with special regard to the effects of inclusions on endurance have recently been made. The final report on cerium has been made by Dr. H. W. Gillett to the Welsbach Company, which is the chief cerium producer and which cooperated in this work, being interested in finding new applications for this metal. A new shape of test bar has been adopted which seems better suited to endurance testing, and over two hundred test bars were prepared and sent out for machining. Metallographic study of inclusions and other causes of fatigue failure has been continued on bars prepared by the Bureau of Mines, and on some obtained from the University of Illinois and the United States Naval Experiment Station.

The Pittsburgh Testing Laboratory announces the opening of a sales office and inspection bureau at 1864 Railway Exchange Building, St. Louis, and the appointment of Col. N. C. Hoyles as district manager.

The Surface Combustion Company, New York, has issued a series of bulletins pertaining to industrial furnaces. One bulletin is devoted to surface combustion low-pressure air-gas inspirators, which are applicable to any gas furnace. A second bulletin is devoted to surface combustion oven furnaces and describes furnaces for the heat treatment of both carbon and high speed steel, etc. A third leaflet is devoted to surface combustion pot-hardening furnaces, a fourth to surface combustion soft metal furnaces ,a fifth to surface combustion galvanizing bath, a sixth to surface combustion shipyard furnaces, a seventh to surface combustion rivet heaters, an eighth to surface combustion small forges, and a ninth to surface combustion laboratory furnaces for high temperatures.

Experimental work on an investigation of the magnetic properties of a series of pure alloys of iron and carbon has recently been completed by the Bureau of Standards, Washington, D. C. A number of alloys were prepared having carbon contents ranging from 0.018 to 1.60 per cent and containing no impurities in sufficient amounts to be of importance. Normal induction and hysteresis data were obtained for magnetizing forces up to 2500 gilberts per centimeter and the results correlated not only with the carbon content but also with heat treatment. The reluctivity relationship previously used in a study of carbon steel with eutectoid composition was found to be useful in correlating the results. A paper describing the results of this investigation is in preparation.

The Firth-Sterling Steel Company of McKeesport, Pa., has opened a western office at 336 East Third street, Los Angeles, California. This office will be in charge of William E.Nelson, who has been engaged in marketing Firth-Sterling steel for twenty years. Mr. Nelson will be assisted by F. J. Kuhlman, L. W. Mead and T. D. Moore.

W. S. Rockwell Company, 50 Church street, New York City, has issued Bulletin No. 242, a supplement to the series of educational papers previously issued by this company and intended to illustrate the variety of methods of applying the principles of proper heating and handling to different manufacturing requirements and shop conditions. This bulletin covers the influence and method of heating on the quality and cost of heat-treated products.

Factory branches and offices have been opened at 222 West Larned street, Detroit, and at 2138 Oliver Building, Pittsburgh, by the Geo. Oldham & Son Company, Baltimore, pneumatic tools. The E. H. Welker Company, Inc., is the agent in charge at Detroit and J. A. Meredith is in charge at Pittsburgh.

The Mansfield Sheet & Tin Plate Company, and the Ohio Corrugating Company, D. B. Coey representative, have moved their sales offices to 910 South Michigan boulevard, Chicago, Room 1018.

M. K. Hitchcock, of the Ohio Refractories Company, Portsmouth, O., has acquired by purchase the Ironton, Ohio fire clay brick plant of the Basic Products Company.

(*Continued on Page* 36)

Temperature

With the **F. and F. Optical Pyrometer** the temperature is measured by merely observing the object. It is accurate, simple and substantial.

(*Write for Booklet*)

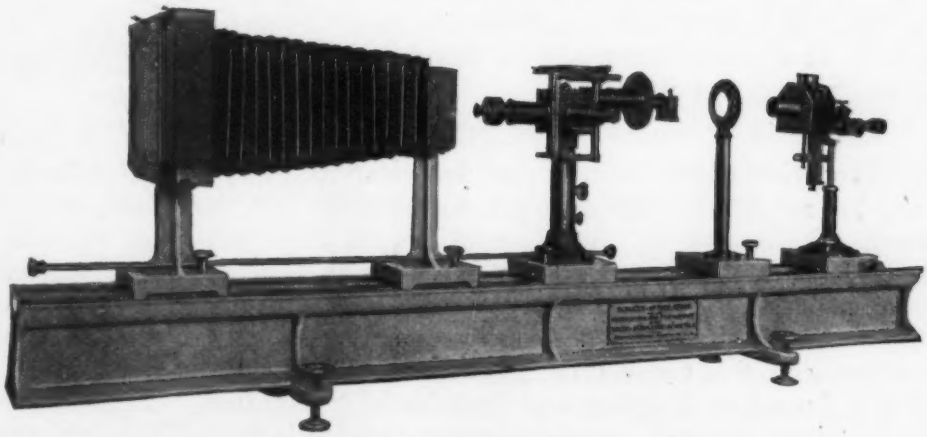
Hardness

The **S. M. Co. Brinell Machine** is the standard machine for measuring hardness of metals adopted by more than 100 leading concerns.

Pressure is applied quickly and uniformly; a special feature prevents leakage of the hydraulic fluid.

(*Ask for Booklet on Hardness Tests*)

Micro-Structure



The **Scimatco Optical Bench** is the advanced outfit used by many of the foremost metallurgical firms for observing and photographing the micro structure of metals.

SCIENTIFIC MATERIALS COMPANY

"Everything for the Laboratory"

PITTSBURGH, PA.

(*Continued from Page* 942)

At the request of Secretary Herbert Hoover ,of the Department of Commerce, the American Engineering Standards Committee will undertake at once a canvass to determine what simplification in manufactured products is most needed and most desirable. This canvass will be conducted through the engineering and technical bodies having representatives on the committee or co-operating in its work. The survey of simplification or standardization needs and possibilities will extend into almost every industry in America.

This assignment to the American Engineering Standards Committee is one of Secretary Hoover's steps to retrieve for American Industry a few of the many billions of dollars wasted annually, as revealed in the report on waste in industry which was made not long ago by a committee also appointed by Mr. Hoover while he was chairman of the Federated American Engineering Societies. The latter committee found that waste in industry was due largely to an over-multiplicity in number of products as well as to inefficiency in process.

Of equaul significance is the fact that Mr. Hoover's request that the American Engineering Standards Committee conduct this survey and the acceptance of the assignment by the committee indicate a co-ordination of the work in the simplification of manufactured products, sponsored by Secretary Hoover, and the work of the American Engineering Standards Committee in the unification of standards on a national basis.

What should be the relationship between the simplification work of the Department of Commerce and the standardization work of the American Engineering Standards Committee has been the subject of considerable discussion. It is clear now that there will be no duplication or overlapping. There seems to be a general recognition of the fact that simplification of product and improvement of process are to a large degree only other words for standardization; that they are standardization put to work. The joint movement for standardization and simplification may, therefore, be said to have begun its work in its own household by standardizing, simplifying, and unifying its own machinery and processes.

The Executive Committee of the American Engineering Standards Committee as, by resolution, pledged the co-operation of the Committee to the Department of Commerce. Representatives of the Committee recently held a conference on the subject with Mr. Hoover at Washington. Subsequently an arrangement was made for permanent exchange of representatives between the two organizations so that there may be of the closest possible co-operation between the Commerce Department's Division of Simplified Practice and the American Engineering Standards Committee.

Great strides toward standardization, particularly in the construction, metals, mining, and electrical industries of Belgium are indicated in a report from the Association Belge de Standardization which has just been received by the American Engineering Standards Committee, 29 West Thirty-ninth street, New York City.

The report shows that the following standards have been approved for issue in Belgium:

Rules for the Construction of Steel Roof Trusses

(*Continued on Page* 38)

Add to Your Employes Comfort

One of these hot days walk thru the room where your carbonizing boxes are packed and dumped. How would *you* like to work in clouds of charcoal and chemical dust when you are sticky with sweat. If you insist on furnishing them with compound which generates excessive dust you *force* them to quit.

You can meet your highest requirement with Bohnite and reduce the discomfort of your men to a minimum.

Ask any hardening room employe using Bohnite and he will emphatically tell you so.

Write *us* for your next supply and improve your working conditions while reducing your cost and increasing your output.

CASE HARDENING SERVICE CO.
2284 Scranton Rd., Cleveland, Ohio

(*Continued from Page* 36)

Rules for the Construction of Steel Tanks

Rules for the Construction of Galvanized, Corrugated Roofs and Partitions

Standardization of Steel Bridges

Tentative List of Equal Angles

Standardization of Shafts and Pulleys

Standardization of Bolts and Rivets

Standard Requirements for Electrical Machinery

Electrotechnical Vocabulary.

These standards with the exception of the Tentative List of Equal Angles have been printed and copies are now available through the American Engineering Standards Committee. The Tentative List of Equal Angles is up for printing.

The report shows also that the following proposed standards have been published in the press of Belgium for criticism.

Rules for the Design and Inspection of Reinforced Concrete Structures

Chains (Dimensions of links; material; reception tests)

Wire Cables for Cranes, Hoists, Elevators and Mining Purposes

The Draft Specification for Methods of Analyses for Zinc Ores, Spelter, etc. is under consideration.

There is also shown in the report that work on the following proposed standards is in the hands of Technical Committees

Cast Iron Pipes and Fittings for Water Works

Rules for the design of Shafting

Standardization of Tolerances

Dimensions of Paper, Drawing, etc.

On the subject of Flanges for Steel Tubes and on Chains (Dimensions of rings and hooks) decisions have been made to undertake standardization.

Copies of pending standards will also be available through the American Engineering Standards Committee as soon as published.

Foregin department of Joseph T. Ryerson & Son has been moved from Chicago to the company's branch offices, 30 Church street, New York. Paul H. Petersen, associated with this department for six years, will be in charge, succeeding H. B. Kraut, who will act as technical manager of the machinery department. The department as in the past will handle both steel and machinery. The company has foreign offices in London, Paris, Tokio, Sydney, Rio de Janerio, Buenos Aires, Lima and Toronto.

In view of the increasing use of Monel metal, it may be of interest to bring out a point developed in the discussion of a paper read last year before the mechanical section of the Engineers' Society of Western Pennsylvania. The authors, Edward S. Wheeler, assistant manager of the technical department, International Nickel Co., and Robert J. McKay, Mellon Institute of Industrial Research, University of Pittsburgh, mention the use of the metal in the process of pickling steel sheets and bars in sulphuric acid. While it appears that the original cost of Monel metal for containers for this work is greater than that of most of the anti-acid bronzes which are used, the resistance of the metal to the acid, combined with its strength and resistance to impact, and to amenability to re-working, make it cheaper in the final analysis.

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SIMONDS
STEEL
CRUCIBLE —— ELECTRIC

High Speed Steel
Magnet Steels
Chrome Ball and Bearing Steels
Carbon and Alloy Tool Steels
Special Steels

TO know that the steel ordered today will duplicate in every respect that which gave unusual efficiency six months ago, is a satisfaction to the consumer made possible only by years of experience in making QUALITY Steels UNIFORM at all times.

SIMONDS STEEL in your hardening room allows you fixed temperatures in heat treating and eliminates those costly "trouble days".

We Develop Steels Required
For Particular Hard Usage

Bars Sheets Billets

SIMONDS MANUFACTURING CO.
STEEL MILLS
LOCKPORT, N. Y.

Edgar T. Ward Sons Co., Distributors

(*Continued from Page* 38)

It was brought out in discussion by L. G. Firth, works manager Firth-Sterling Co., McKeesport, Pa., that at Sheffield, England, progress had been made in hardening Monel metal in a manner similar to steel. The International Nickel Co. has also been working on this problem. It has found that some reaction may be obtained from heat treatment, but nothing to compare with the tempering of steel. Experiments are still in process.

In answer to the increased demand for seamless tubes of Monel metal, the International Nickel Co. has been making a special effort to produce them commercially. However, the great strength of the metal at high temperatures has rendered the problem difficult. The billets must be very hot and evenly heated and the heating atmosphere must be carefully controlled at this high heat.

Theodore G. Selleck, Consulting Metallurgical Engineer and expert in the heat treatment of steels announces the opening of his new office located at 20 East Jackson boulevard, Chicago. Mr. Selleck has had a broad practical experience in the field of carburizing and heat treating, having devoted years to the study and investigation of steel treating problems. Mr. Selleck is specializing in the design and installation of steel treating, handling and carburizing plants. His advice and assistance to any who are contemplating the installation or rearrangement of their plants is invaluable.

The Scientific Materials of Pittsburgh have recently issued a bulletin describing their optical pyrometer. This bulletin covers the practical industrial applications, a general theory of optical pyrometry, a temperature scale and a general description of and simple instructions in operating their instrument. This bulletin is illustrated showing the practical shop applications of the optical pyrometer.

The Wilson Maeulen Company, 383 Concord avenue, New York City, makers of the Direct Rockwell Hardness Tester have recently issued a bulletin describing in detail the operation of the Rockwell Hardness Tester and its application to industrial testing.

E. J. Lowry, formerly metallurgist, Oliver Chilled Plow Works, South Bend, Ind., has become identified with Hickman, Williams & Co., pig iron brokers, as a service engineer. In that capacity his services will be offered gratis to foundries having any difficulties in solving the physical and chemical problems of their castings work. He will divide his time between the various offices of the company at Chicago, Cincinnati, Pittsburgh, St. Louis, New York, Philadelphia and Birmingham. His education and subsequent experience have been largely in the metallurgical field. After three years at the United States Naval Academy at Annapolis, he took up special work in metallurgy at Harvard University and the Massachusetts Institute of Technology. He was then for two years a foreman in the steel foundries of the United States Arsenal at Watertown, Mass., and later foundry foreman at the United States Cartridge Co., Lowell, Mass. As metallurgist for the Oliver Chilled Plow Works, he also was called in for consultation work at other plants, including those of the Ford Motor Co., Detroit; the Studebaker Corporation, South Bend, and the Walworth Mfg. Co., Kewanee, Ill.

Mr. Lowry is also a member of the American Society for Steel Treating.

(*Continued on Page* 42)

HEL-LO!

Wait a minute, please!

Want to make some money?

All right. Look up your back Transactions and send us right away, the ones we need and we'll send you 75c each.

WE WANT:

100 Copies, Transactions January 1921, Vol. 1. No. 4

We advertised for the March, 1921 issue and received about 50 copies. Not enough, so we had to order a reprint of that number. Can't use any more Marchs, but send today those requested above.

Shipping Instructions

Mail to

AMERICAN SOCIETY FOR STEEL TREATING
4600 PROSPECT AVE.
CLEVELAND, OHIO

If you place your address on the outside of package you will not need to write a letter. Trust us and Uncle Sam to send you a check.

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Roy C. McKenna, President of Vanadium-Alloys Steel Co., Latrobe, Pa., has been elected president of the University of Pittsburgh Alumni association.

A 20-page periodical published by the Metal & Thermit Corporation, illustrates and describes many applications of thermit welding. The elimination of blow holes in thermit welds by the use of new molding material and new style mold boxes, and how the cost of thermit-welding large sections of locomotive frames may be greatly reduced are discussed. Another item shows how the Garfield Smelting Co., Garfield, Utah, has been able to effect a large saving in the repair of ladle spouts by the thermit process.

Several series of "sequence etchings" have been tried out by the Bureau of Standards on a specimen of high-speed steel which was in the "as received from the mill" condition. Sequence etching means the etching with two or three reagents in successive order without any repolishing of the section between the etchings, and the taking of photomicrographs after each etching at the same spot in the microsection in order to note any changes in microstructure produced by the last etching as compared with that developed by the preceding etching reagent.

The reagents used in various combinations were (1) Dilute ammonium hydroxide solution together with a weak electric current, the specimen being made positive pole; (2) two per cent alcoholic solution of nitric acid; (3) boiling sodium picrate, and (4) Murakami's reagent (solution of potassium ferricyanide and sodium hydroxide) at boiling temperature.

The results, as judged from the behavior toward the various etching reagents tried, appear to show that there are at least three different constituents present among the imbedded globules or particles in the specimen of high-speed steel, in the "as received from the mill condition," though any attempt to state the nature of these constituents would, in view of present developments, involve speculation.

The Electric Furnace Construction Co., Philadelphia, has published a 20-page illustrated booklet in which electric furnaces for melting, refining and superheating iron and steel are described and illustrated. According to the booklet the heat in these furnaces is generated above and below the bath and can be regulated over a wide range. The hearth is at least 20 inches thick. They are suitable for a two-phase or three-phase electric current and if one arc is broken the other arcs are not affected.

Indicating and multi-recording types of radiation pyrometers are described and illustrated in a 16-page illustrated booklet recently published by the Thwing Instrument Co., Philadelphia. According to the booklet, this instrument furnishes a rapid method for measuring temperatures in metallurgical and ceramic operations in furnaces, cement kilns, coke ovens, boiler fire pits, and in measuring local temperatures of dies in the hardening furnace, etc. This pyrometer has two parts. One is a receiving tube which collects the radiations from the hot body on a conical mirror, which in turn concentrates them upon a highly sensitive black thermocouple, and the second, a galvanometer, with wire connections to the thermocouple to measure the current generated in it by the radiations.